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REPORT ON

RESOURCE AND POTENTIAL RECLAMATION EVALUATION OF

OTTER CREEK EAST STUDY SITE OTTER CREEK COALFIELD MONTANA 1977

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RESOURCE AND POTENTIAL RECLAMATION EVALUATION

OF

OTTER CREEK EAST STUDY SITE
OTTER CREEK COAL FIELD, MONTANA

CONTENTS

	Page
Introduction	1
Purpose	1
Authority	1
Location	1
Climate	3
Physiography	6
Geology	7
Regional Geology	7
Site Geology	8
Investigations	8
Stratigraphy	8
Coal Resources	12
Land Classification	16
Description of the Land	16
Alluvial Soils	16
Colluvial Soils	16
Residual Soils	18
Description of Classes	18
Methods and Procedures	19
Results of Classification	19
Soil Inventory	21
Reclamation Potential	21

PLATES

Plate 1 - General Location Map	2
Plate 2 - Geologic and Investigations Map	9
Plate 3 - Geologic Log of DH76-101	10
Plate 4 - Semi-Detail Land Classification	20
Plate 5 - Suitability of Material for Plant Media	22
Plate 6 - Soils Map	23

TABLES

Table 1 - Potential Consumptive Use of Moisture and Available Moisture-Native Grasses	4
Tables 2 through 4 - Coal Analyses	13-15
Table 5 - Land Classification Specifications	17
Tables 6 through 13 - Erosion Evaluation and Soil Profile Descriptions	24-31
Table 14 - Laboratory Analyses	32-49

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RESOURCE AND POTENTIAL RECLAMATION EVALUATION OF OTTER CREEK EAST STUDY SITE OTTER CREEK COAL FIELD, MONTANA

INTRODUCTION

A growing and affluent society is creating an ever increasing need for energy. Attention has focused on the coal resources existent in the Western States, primarily the Rocky Mountain and the Northern Great Plains regions, due to the abundance, ease of extraction, and the quality of the coal present. It is the responsibility of the Bureau of Land Management to assist in meeting these energy demands and, at the same time, provide sound reclamation and rehabilitative guidelines so that the lands subjected to disturbance are returned to a useful condition.

Purpose

The purpose of this study is to provide data for reclamation objectives at a potential coal leasing area. The site was selected to determine if existing data collected for the nearby Otter Creek Study Site (EMRIA No. 1) could be correlated or projected throughout the Otter Creek Coalfield.

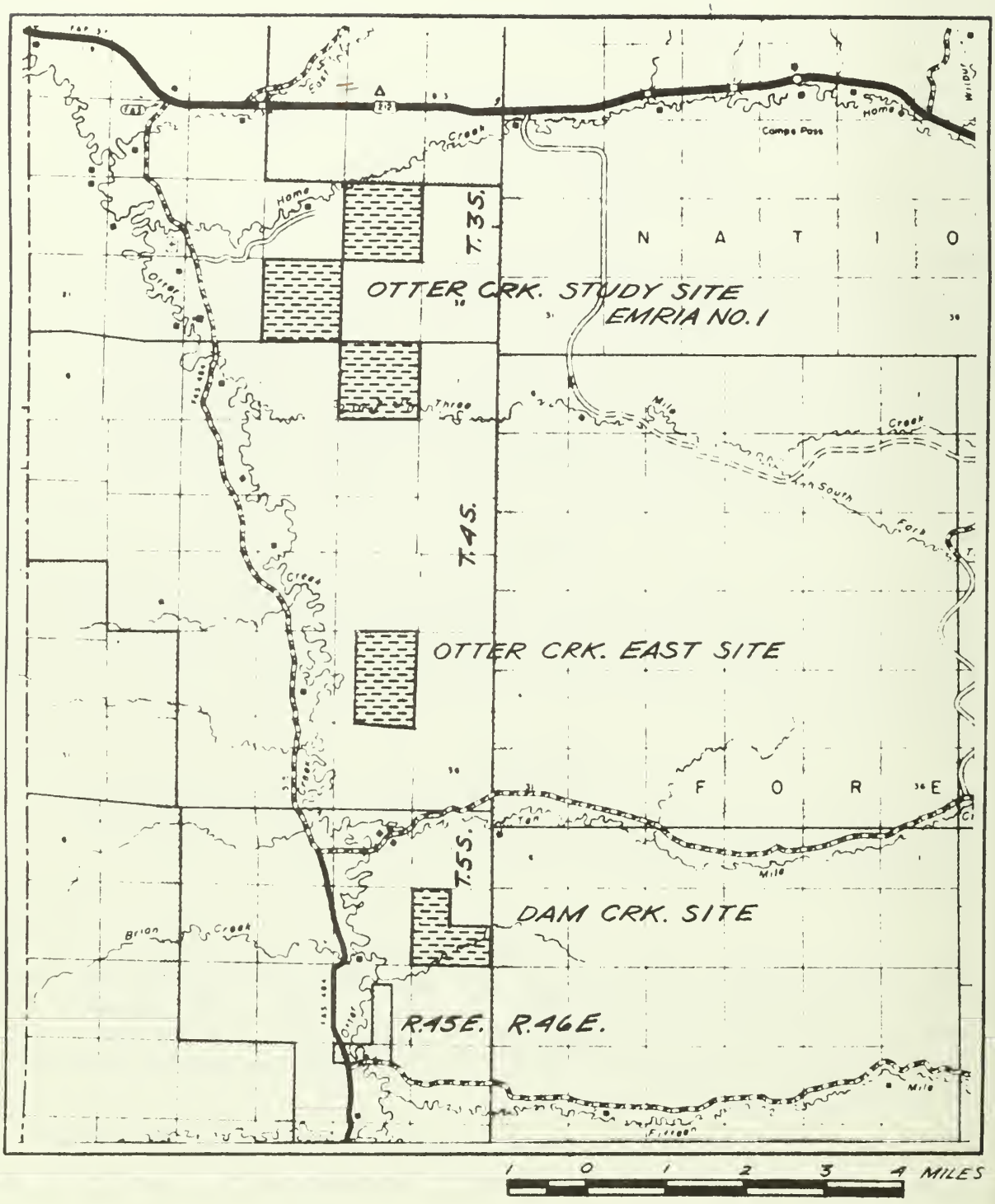
Authority

This report is prepared in accordance with Section 4 of the Agreement between the Bureau of Land Management and the Bureau of Reclamation dated May 7, 1974.

Location

The Otter Creek East Site is located in Powder River County, about 11 miles southeast of Ashland, Montana. The site, which includes the eastern three-fourths of Section 26, T. 4 S., R. 45 E., lies between the Otter Creek Study Site (EMRIA No. 1) completed in 1975 and the Dam Creek Site investigated in 1976. Plate 1 shows the general location of all three sites.

The Federal Government owns all coal deposits in the site. The surface is privately owned.



GENERAL LOCATION MAP
FOR
OTTER CREEK STUDY SITE (EMRIA NO. 1)
OTTER CREEK EAST SITE
AND
DAM CREEK SITE

CLIMATE

The Otter Creek East Study Site is in the Otter Creek geographical area which has a continental-type climate. It is cold in the winter, warm in the summer and large diurnal variations are common. Elevation at the site ranges from 3100 feet to 3386 feet. The Broadus weather station at elevation 3030 feet receives 14.2 inches average annual precipitation and Birney, at elevation 3190 feet, receives an average of 13.7 inches annually. Torrential rainstorms are common and unprotected soil surfaces may erode severely during these storms. These storms, though common, may not cover large areas. Hailstorms occasionally cross the area, but these weather extremes do not place the area in any particular type storm belt. About 53 percent of the precipitation falls as rain during the growing season. Growth of native range is rapid during May and June which are the wettest months of the year. Precipitation data from the Otter weather station 27 miles southwest of this site follow:

May	June	July	August	Sept.	Percent of Annual	Annual
2.51	3.30	1.32	1.26	1.69	53	1910[1/]

The elevation of the Otter station is 4000 feet.

The frost-free period (32°F.) ranges from 108 days at Birney to 120 days at Broadus. The growing season for hardy grasses (28°F.) in average years begins May 10 at Birney and ends 131 days later on September 19. Following the spring rains, July is hot, dry and windy with excessive evaporation and evapotranspiration rates. Humidity is low. During the months of June, July and August, about 32 days have a temperature of 90°F. or higher. Average monthly temperatures exceed 51°F. in May, June, July, August, September and October. July, with an average temperature of 74°F., is the hottest month and May and October with 51°F. are the coolest growing season months.

The climate in the Otter Creek area in most years is suited for reclamation of surface-mined land because the spring rains are generally adequate for establishing stands of native vegetation. The 13.7 to 14.2 inches of precipitation received in average years meet the requirement of range vegetation which grows rapidly in the late spring and early summer. This moisture from natural precipitation is usually depleted by established native grasses in 6 to 8 weeks and the plants mature and become dormant. Consumptive use data in table 1 show native grasses could use 22.5 inches of moisture if available; but it also shows that 13.9 inches or the average annual precipitation could be used by July 15. Table 1 prepared for the Otter Creek study site also represents the potential consumptive use in this site.

1/ The Otter station is several hundred feet higher than this study site. The apparent effect is an increase in the precipitation especially during the nongrowing season.

Table 1 - Potential Consumptive Use of Moisture and Available Moisture - Native Grasses [1]

Otter Creek East Study Site

Month	Midpoint	Accumulative Days to Midpoint	Mean Air Temp. (°F)	Monthly Requirement Inches	Moisture Reserve Inches [2]	Precipitation Inches	Difference Inches [3]
May 4					+4.04		
	May 17	13	54.6	2.80		2.23	+3.47
June					+3.37		
	June 15	42	63.1	4.75		3.13	+1.85
July					+1.85		
	July 15	72	71.2	6.36		1.36	-3.15 [4]
August					-3.15		
	Aug. 15	103	69.8	5.52		1.08	-7.59
Sept.					-7.59		
	Sept. 13	131	58.2	3.05		1.20	-9.44
Sept. 27		145					
				22.48		9.00	

1/ Computed by Blaney-Criddle Method using the Broadus Weather Station - Latitude 45°26'N

2/ Moisture Reserve = Summation of precipitation (Oct. to April) = 5.05 x 0.80 = 4.04 inches

3/ Difference = Moisture Reserve plus precipitation minus moisture use

4/ Natural precipitation during most years is inadequate to meet potential moisture needs. In average years, the plants use the available moisture by July 15 and mature and become dormant.

Reclamation of surface-mined land is very difficult in areas that consistently receive 10 inches of precipitation or less each year. In this area years with less than 10 inches of annual precipitation are not common. The Broadus station reported less than 10 inches only three times in the last 37 years and Birney only once in the last 21 years.

PHYSIOGRAPHY

Otter Creek East Study Site is in the unglaciated segment of the Missouri Plateau. The elevation within the site ranges from 3100 feet to 3386 feet. Erosion of the sedimentary formations has produced distinctive sandstone ridges, mesas, and escarpments, which dominate much of the landscape in the undulating and hilly uplands in and around the Otter Creek site. Erosional forces have also developed a branching drainage pattern that flows generally northward to the Yellowstone River. These natural drains empty into Otter Creek which is the only perennial stream near the study area. It has a moderately wide alluvial valley with an incised channel.

The surface relief within this site consists of relatively smooth slopes, colluvial footslopes, small alluvial valleys, rocky outcrops, massive sandstone remnants and some severely eroded minibadland tracts. The massive sandstone rises up to 20 feet above the surrounding land.

Normal stripping and stockpiling of surface material cannot be carried out in tracts with minibadlands, rock outcrops and massive sandstone remnants.

GEOLOGY

Regional Geology

The Otter Creek East Study Site is located in the northern part of the Powder River Basin in southeastern Montana. This basin, a part of the unglaciated portion of the Great Plains physiographic province, is about 225 miles long, extending from the Yellowstone River in Montana to the North Platte River in Wyoming. It is about 90 miles in width, bounded on the west by the Bighorn Mountains and on the east by the Black Hills. Structurally, the basin is an asymmetrical syncline with a northwestward trending axis. An estimated 18,000 feet of sediments overlie the basement complex in the deepest part of the basin north of Glenrock, Wyoming.

The geologic history of the area since Precambrian time includes periods of deposition, deformation, and erosion. During the Paleozoic and Mesozoic Eras, a sequence of carbonates, sandstones, and shales were deposited throughout Montana and Wyoming. Thickness of these sediments on the west side of the basin varies from 9,000 feet near Yellowtail Dam to 11,500 feet near Buffalo, Wyoming. About 6,500 feet of Paleozoic and Mesozoic sediments are present in the Black Hills area on the east side of the basin.

The area was relatively stable during these periods with deposition occurring generally under a marine environment. Deformation of these strata began with the Laramide Revolution near the close of the Mesozoic Era (Late Cretaceous), at which time mountain masses such as the Bighorns and Black Hills were uplifted. Uplift continued throughout Paleocene and gradually ended in Eocene time. Materials stripped from the mountains were deposited in fans or sheets across the basin floors, gradually burying the flanks of the mountains in their own debris. By the middle of the Cenozoic Era, the basins were largely filled and the mountains peneplained. In Pliocene time, a broad regional uplift occurred and continued intermittently into Pleistocene time. This uplift raised the previously developed peneplain surface to elevations of about 10,000 feet in the Bighorn Mountains. Streams rejuvenated by the uplift excavated the basins and exhumed the buried mountain masses.

Today, Precambrian rocks are exposed in the cores of the Black Hills and Bighorn Mountains. These rocks are surrounded by sediments of the Paleozoic and Mesozoic Age. The central part of the basin is filled with Cenozoic (Tertiary) sediments.

Site Geology

Investigations

Previous geologic investigations were conducted in the area by the U.S. Geological Survey and the Montana Bureau of Mines and Geology. Publications covering this are listed as follows:

1. U.S.G.S. Bulletin 1072-J - Reconnaissance Geology of the Birney-Broadus Coal Field, Rosebud and Powder River Counties, Montana.

2. Montana Bureau of Mines and Geology Bulletin 91 - Quality and Reserves of Strippable Coal, Selected Deposits, Southeastern Montana.

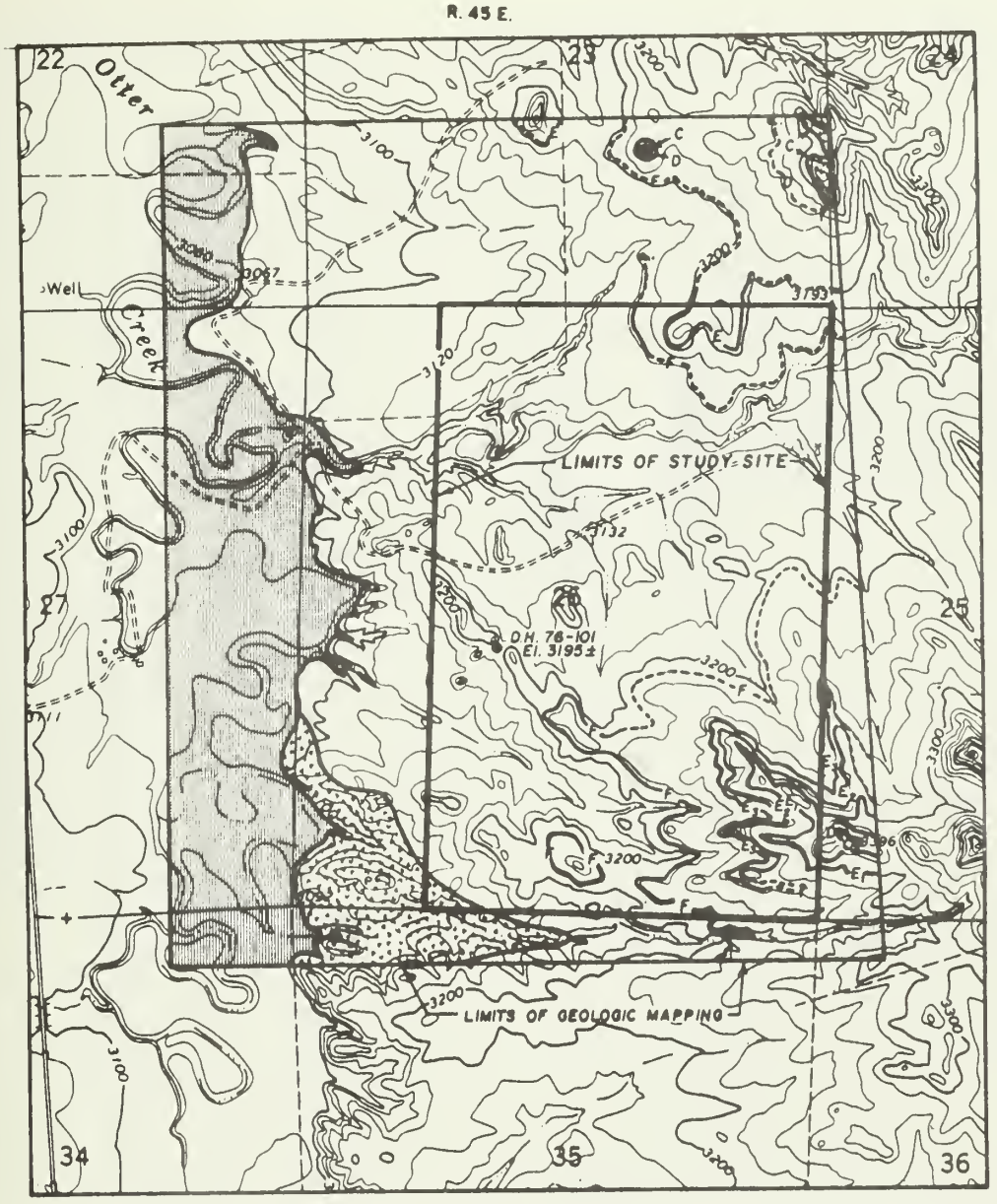
Geologic investigations were conducted on the Otter Creek East mini-site by the U.S. Bureau of Reclamation during May and June of 1976. These investigations included mapping the surface geology and drilling one core hole. Detailed geologic mapping on a scale of 1 inch equals 1,000 feet was done in the field on aerial photographs. These data were transferred to a topographic map and are shown on Plate 2. A detailed geologic log for Drill Hole 76-101 is included in this report (Plate 3).

Core drilling was performed using a Failing Model 314 rotary drill rig with an "H" series wire line core barrel. Water from Otter Creek was used as the drilling fluid. Test results conducted by the U.S.B.R. Soils Laboratory in Miles City, Montana, indicated that the total dissolved solids in the water supply was about 1900 parts per million.

Perforated 2-inch-diameter plastic pipe was installed in the drill hole for possible future ground water monitoring.

Stratigraphy

The Fort Union Formation of Paleocene Age underlies the entire area. It is divided into the Tullock, Lebo and Tongue River Members. The Tullock and Lebo Members will not be discussed in this report as they are not exposed and were not encountered in drilling. Except for alluvium, only sediments in the lower part of the Tongue River Member are involved in the study area. The upper part of the Tongue River and younger sediments have been stripped away by erosion. Brief descriptions of the Cenozoic sediments involved in the site follow:



EXPLANATION

RECENT — ALLUVIUM - Clay, silt, sand and gravel Up to 50 feet thick

PALEOCENE — FT UNION FM (TONGUE RIVER MEMBER) - Interbedded shale, siltstone, sandstone and coal.

CLINKER - Baked shale, siltstone and sandstone of the Fort Union Formation. Produced by burning of the Knoblock and Odell(?) coal beds. Up to 100 feet thick.

—C— C through F - Coal and/or carbonaceous shale beds
- C - Odell(?) coal bed. Burned at outcrop. Probably over 5 feet thick
- D - 2 to 3 feet of carbonaceous shale with thin coal streaks
- E - Includes E_1, E_2 and E_3 - Carbonaceous shale beds up to 5 feet thick.
- F - 1 to 2 feet of coal - Probably corresponds to "C" bed in Otter Creek Study Site. (EMRIA Report # 1)

Note: Clinker in the SW corner of Section 26 was produced by burning of the underlying Knoblock coal bed

Odell(?) coal bed burned at outcrop

● O H 76-101 El. 3195 ± USBR DRILL HOLE (Elevation at ground surface)

1000 0 1000 2000 3000
SCALE OF FEET

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

RESOURCE & POTENTIAL RECLAMATION EVALUATION

OTTER CREEK EAST SITE
OTTER CREEK COALFIELD, MONT.

GEOLOGIC AND INVESTIGATIONS MAP

GEOLOGY - S. JOHNSON ..... SUBMITTED .....
DRAWN - L.E. ALLOOP ..... RECOMMENDED .....
CHECKED ..... APPROVED .....

BILLINGS, MONTANA JUNE 1976 | 1305-600-107

7-1337 (8-69)
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GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 3

FEATURE Otter Creek East Site — Otter Creek Coal Field — PROJECT Work Order 002 — STATE Montana

HOLE NO. DH76-101 — LOCATION * — GROUND ELEV. 3195± — DIP (ANGLE FROM HORIZ.) Vertical

BEGUN 5/25/76 — FINISHED 6/3/76 — TOTAL DEPTH 234.0 — BEARING --

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED 119.7'6/3/76 (3075.3) — LOGGED BY Taucher — LOG REVIEWED BY

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	BOILS ANALYSIS SAMPLE DEPTH (FEET) FROM	BOILS ANALYSIS SAMPLE DEPTH (FEET) TO	SUITABILITY FOR RECONSTRUCTED PROFILE: SUITABLE	LIMITED SUITABILITY	UNSUITABLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
5/24/76 - Moved rig & equipment to Ashland, Mont. 5/25/76 - Moved equipment to drill site. Nx drive samples 0 to 9.0-ft. Set 5-in. Cs to 9.0-ft. HQ wireline core 9.0 to 23.5-ft Dropped core 18.0 to 23.5-ft. Hole at 23.5-ft. 5/26/76. 5-in. Cs at 9.0-ft. Hole dry. HQ wireline core 23.5 to 82.0-ft. Used "Reverc" 23.5 to 42.0-ft. Hole at 82.0-ft. 5/27/76. 5-in. Cs at 9.0-ft. W.L. at 33.4-ft. HQ wireline core 82.0 to 134.5-ft. Driller reported washing away aoft, uncemented aandatone 102.0 to 112.0-ft. Could not recover coal samples 114.5 to 124.5-ft. *2800' N. & 2130'E. of SW Corner Section 26, T. 4 S., R. 45 E.		100 94 01 100 100 11 45 100 47 100 02 40.0	0	36.0				3159.0 3155.0	36.0			FT.UNION FORMATION - PALEOCENE 0-36.0 SANDSTONE: tan; oxidized; damp becoming moist with depth; fine, uniform; trace of cement in zones; pulverizes easily between fingers; thin-bedded; active acid reaction; trace of silt; highly weathered (disintegrated) to 8.0-ft; poorly formed core below 8.0-ft. 36.0-40.0 LIMESTONE: light to medium gray; very hard; scratches with knife; active acid reaction; highly oxidized 36.0 to 36.1-ft; several 90° fractures; breaks along bedding planes on 1/2 to 3-in. centers. 40.0-100.8 SHALE & SANDSTONE: alternating zones of silty shale & sandstone shales are medium gray moderately firm (difficult trimming by knife) and moderately plastic sandstones are light gray, uncemented, fine grain and crush easily between fingers; slight to moderate HCl reaction; moist; core lengths up to 12-in. 40.0-47.7 - thin-bedded to laminated shale and silty shale 47.7-58.0 - alternating laminations of shale, fine grain sandstone and siltatone; shale comprises about 60% of sample 58.0-62.0 - thin-bedded to laminated shale and silty shale 62.0-63.3 - very weakly cemented fine grain sandstone 63.3-100.8 - moderately plastic shale with sandstone streaks becoming more plastic with depth; air slakes in places; uncemented fine grain sandstone 64.7 to 65.0, 65.5 to 65.6, 72.7-72.9, 76.4-76.6 and 86.9-87.1 ft., laminated shale (60%) and fine grain sandstone (40%) 72.9 to 76.4 & 76.6 to 77.9-ft.; 1-inch limestone nodules at 71.6 & 89.0-ft. slightly carbonaceous 97.0 to 100.8-ft. with 1/8-in. coal streak at 100.7-ft. 100.8-112.0 SANDSTONE(?): driller reported washing away uncemented
		100 87 90	02 40.0	100.8								

EXPLANATION

CORE LOSS / CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-sailes) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-sailes) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-sailes). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-sailes) . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Otter Creek East Site — Otter Creek Coal Field — PROJECT Work Order 002 STATE Montana — SHEET 1 OF 3 — HOLE NO. DH76-101

7-1337 (8-69)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 2 OF 3

FEATURE Otter Creek East Site — Otter Creek Coal Field — PROJECT Work Order 002 — STATE Montana

HOLE NO. DH76-101 — LOCATION * — GROUND ELEV. 3195± — DIP (ANGLE FROM HORIZ.) Vertical

BEGUN 5/25/76 — FINISHED 6/3/76 — TOTAL DEPTH 234.0 — BEARING --

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED 119.7'6/3/76 (3075.3) — LOGGED BY Taucher — LOG REVIEWED BY

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	BOILS ANALYSIS SAMPLE DEPTH (FEET) FROM	BOILS ANALYSIS SAMPLE DEPTH (FEET) TO	SUITABILITY FOR RECONSTRUCTED PROFILE: SUITABLE	LIMITED SUITABILITY	UNSUITABLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Hole at 134.5'. 5/28/76. 5" Cs at 9.0'. W.L. at 59.5'. HQ wireline core 134.5 to 164.0'. 50% water loss at 154'. Hole at 164.0'. 6/1/76. 5" Cs at 9.0'. W.L. at 113.7'. Hole caved at 130.0'. Cleaned out hole. HQ wireline core 164.0 to 214.0'. 50% water loss. *2800' N. & 2130' E. of SW Corner, Section 26, T. 4 S., R. 45 E.		0 60 0 40 100 100 03 157.0 162.7 Minus sandstone 04 165.6 173.0 05 174.0 210.0						3094.2 3083.0 3038.0 3032.3 3030.7 3029.4 3022.0 3021.0	100.8 112.0 157.0 162.7 164.3 165.6 173.0 174.0			sandstone (no sample 102.0-112.0'); core 100.8 to 102.0' was slightly cemented, fine grain sandstone that was calcareous and difficult to crush between fingers. 112.0-157.0 COAL: Black; wet; badly broken to shattered to 135.0'; broken in 2 to 12" core lengths below 135.0'; driller reported shale 134.5 to 134.8'. 157.0-162.7 SHALE: Dark gray becoming medium gray with depth; moist; firm; trims by knife with difficulty; plastic; carbonaceous; less carbonaceous with depth; 35 to 50° slickensides on about 6" centers; hard cemented fine grain sandstone (scratches with knife) 161.7 to 162.5'; core lengths 3 to 12". 162.7-164.3 SILTSTONE: Light gray; moist; firm; trims by knife with difficulty; bedding not discernible; slightly plastic; core lengths 6 to 18". 164.3-165.6 SHALE: Medium gray; moist; plastic; air slakes; trims by knife with difficulty. 165.6-173.0 SILTY SANDSTONE: Light gray; moist; generally uncemented; crumbles easily between fingers; fine grain; uniform; silty; bedding not readily discernible; 3-24" lengths. 165.6-167.0 - silty sandstone 167.0-167.5 - cemented silty sandstone 167.5-171.7 - silty sandstone 171.7-172.2 - hard, cemented claystone 172.2-173.0 - weakly cemented (calcareous) sandstone 173.0-174.0 CLAYSTONE: Medium gray; hard; scratches by knife; 2 to 3" core lengths. 174.0-210.0 SANDSTONE: Light gray; moist; very fine to fine grain; weakly cemented; crumbles between fingers with difficulty; silty 174.0 to 186.5'; becoming coarser grain below 204.0'; laminated to thin-bedded 174.0 to 190.0'; silty shale 183.3 to 184.3'; core lengths 3 to 12".

EXPLANATION

CORE LOSS / CORE RECOVERY

Type of hole . . . . . D = Diamond, N = Noystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-sailes) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-sailes) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-sailes). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-sailes) . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Otter Creek East Site — Otter Creek Coal Field — PROJECT Work Order 002 STATE Montana — SHEET 2 OF 3 — HOLE NO. DH76-101

7-1337 (8-69)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 3 OF 3

FEATURE Otter Creek East Site — Otter Creek Coal Field — PROJECT Work Order 002 — STATE Montana

HOLE NO. DH76-101 — LOCATION * — GROUND ELEV. 3195± — DIP (ANGLE FROM HORIZ.) Vertical

BEGUN 5/25/76 — FINISHED 6/3/76 — TOTAL DEPTH 234.0 — BEARING --

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED 119.7'6/3/76 (3075.3) — LOGGED BY Taucher — LOG REVIEWED BY

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	BOILS ANALYSIS SAMPLE DEPTH (FEET) FROM	BOILS ANALYSIS SAMPLE DEPTH (FEET) TO	SUITABILITY FOR RECONSTRUCTED PROFILE: SUITABLE	LIMITED SUITABILITY	UNSUITABLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Hole at 214.0'. 6/2/76. 5" Cs at 9.0'. W.L. at 113.7'. HQ wireline core 214.0 to 234.0'. Flushed hole with clean water. Picked up plastic pipe in Ashland. Hole at 234.0'. 6/3/76. 5" Cs at 9.0'. W.L. at 119.7'. Dropped 170' of plastic pipe in hole. Fished for and recovered pipe. Installed 2" plastic pipe to 234.0'. (1.2' stick-up). Pipe slotted 112.0 to 157.0 and 210.0 to 227.3'. Sand packed pipe in perforated zones. Sand and bentonite pack between coal zones. Moved equipment. *2800' N & 2130' E. of SW Corner, Section 26, T. 4 S., R. 45 E.		100 100 100 06 227.3	234.0					2985.0 2967.7 2961.0	210 220 227.3 230 234.0			210-227.3 COAL: Black; wet; badly broken to shattered 214.0 to 215.0'; shattered 215.0 to 224.0'; 3 to 4" core lengths 210.0 to 214.0 and 224.0 to 227.3'. 227.3-234.0 SILTY SHALE: Light gray; moist; firm; thin-bedded; moderately plastic; becoming more silty and approaching clayey siltatone below 231.0'; distorted bedding below 231.0'; very weak HCl reaction; cuts fairly easy with knife; silty zones tend to crumble between fingers.

EXPLANATION

CORE LOSS / CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-sailes) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-sailes) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-sailes). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-sailes) . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Otter Creek East Site — Otter Creek Coal Field — PROJECT Work Order 002 STATE Montana — SHEET 3 OF 3 — HOLE NO. DH76-101

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

RESOURCE & POTENTIAL RECLAMATION EVALUATION

OTTER CREEK EAST SITE
OTTER CREEK COALFIELD, MONT.

GEOLOGIC LOG OF DH 76-101

GEOLOGY G.J. TAUCHER — SUBMITTED

DRAWN — RECOMMENDED

CHECKED — APPROVED

BILLINGS, MONTANA — FEB, 1977 — 1305-600-110

Fort Union Formation (Paleocene Age)

Tongue River Member - pale-olive to yellowish gray sandstone, siltstone, shale, carbonaceous shale and coal with thin lenticular calcareous or siliceous cemented concretions. Unweathered samples vary from light to dark gray in color. Poorly silicified, fragmented tree trunks and soft, calcareous shell fragments are common in zones. Sandstones, even though uncemented, tend to be resistant in outcrops. Exposures of sandstone along drainage divides in the Otter Creek East Site have been eroded to a badland-type topography. Shale and siltstone zones generally form slopes below sandstone ledges. Coal and carbonaceous beds are generally traceable over large areas. Conversely, correlation of clastic sediments over short distances is difficult due to variation in bedding thickness and lithologic changes. Tongue River sediments were deposited in a continental environment which included swamps conducive to the production of coalbeds. Thickness of this member varies from 1150 to 1900 feet in the Montana portion of the Powder River Basin.

One striking feature in the Tongue River Member is the resistant clinker zones that cap ridges or armor valley walls. The clinker, which is fused or baked rock, was produced by the burning of underlying coalbeds along their outcrops. In places where the heat was sufficiently intense, the clinker has been fused to a dark gray, lightweight rock similar in appearance to vesicular basalt. Near the outer edge of thermal metamorphism, the rock is disoriented, baked and red to orange in color. Alteration of the overlying material is roughly proportional to the original thickness of coal that has burned. A coalbed 20 feet thick will produce clinker zones 40 to 60 feet thick. The clinker is highly permeable and locally supplies water for springs and wells.

The most prominent clinker deposit at the minisite was produced by burning of the Knoblock coalbed. Outcrops of clinker occur along the valley walls of Otter Creek and its tributaries as shown on Plate 2. A second minor clinker, produced by burning of the Odell coalbed, lies 200 to 300 feet above the Knoblock coal.

Only the Knoblock coalbed is of economic significance at the minisite. The Knoblock thins and splits into several benches between the Otter Creek Study Site (EMRIA No. 1) and the Dam Creek minisite, a distance of about 7 miles. At the Otter Creek Study Site, the Knoblock averages about 61 feet in thickness. Three to four miles south at the Otter Creek East Site, the Knoblock splits into an upper and lower bench, 45 and 17 feet thick, respectively. The

upper bench thins to about 24 feet thick at the Dam Creek Site, approximately 2 miles south of the Otter Creek East Site. Geologic data in the Montana Bureau of Mines and Geology Bulletin 91 indicates that lower benches of the Knoblock in the Dam Creek area are insignificant.

Alluvium (Recent Age) - consists of clay, silt, sand and gravel that cover valley floors of Otter Creek and its tributaries. Gravels are generally composed of clinker or hard shale and sandstone fragments. Up to 20 feet thick.

Coal Resources

Coal reserves and stripping ratios were not calculated for the Otter Creek East Site as data were insufficient to determine reliable quantities.

The proximate, ultimate, Btu and sulfur forms analyses were completed by Northern Testing Laboratories in Billings, Montana, on three composite coal samples from the minisite. Test results are shown on Tables 2 through 4. Results indicate that the coal is of subbituminous C rank, averaging 8,476 Btu as received. The average ash and sulfur content as received is 6.33 and .28 percent, respectively.

NORTHERN TESTING LABORATORIES

GREAT FALLS • BILLINGS MONTANA • BOISE IDAHO

eport of: Coal Analysis

Date August 17, 1976
Job Number 61-114-1
Sheet 1 of 1

eport to: BUREAU OF RECLAMATION (2)
316 North 26th Street
Room 2425 - Federal Building
Billings, Montana 59103

Sample Identification:

On July 8, 1976, this coal sample was delivered to our laboratory with instructions to perform the following analyses.

TEST RESULTS:

Sample #1

Area : Otter Creek East
Depth, Feet: 112.0 to 139.5
Lab No. : 62642

Analysis	Proximate	Ultimate		Sulfur Forms	
% Moisture:		% Carbon:		Pyritic Sulfur:	
As Received	28.48	As Received	49.15	As Received:	0.03
Air Dry Loss	10.00	Air Dry	54.62	Air Dry	0.03
Oven Dry Loss	20.54	Oven Dry	68.73	Oven Dry	0.04
% Ash:		% Hydrogen**:		Sulfate Sulfur:	
As Received	5.41	As Received	6.45	As Received	0.02
Air Dry	6.02	Air Dry	5.92	Air Dry	0.02
Oven Dry	7.57	Oven Dry	4.56	Oven Dry	0.03
% Volatile:		% Nitrogen:		Organic Sulfur:	
As Received	28.40	As Received	0.80	As Received	0.17
Air Dry	31.56	Air Dry	0.89	Air Dry	0.19
Oven Dry	39.71	Oven Dry	1.12	Oven Dry	0.23
% Fixed Carbon:		% Oxygen:**		Total Sulfur:	
As Received	37.71	As Received	37.97	As Received	0.22
Air Dry	41.88	Air Dry	32.31	Air Dry	0.24
Oven Dry	52.72	Oven Dry	17.72	Oven Dry	0.30
% Sulfur:					
As Received	0.22				
Air Dry	0.24				
Oven Dry	0.30				
BTU, per pound:					
As Received	8,488				
Air Dry	9,432				
Oven Dry	11,870				
BTU, per pound:					
Ash, moist free	12,842				

**Includes coal moisture content in accordance with ASTM D3176.

Certified Gary L. O'Dell

NTL—110

NORTHERN TESTING LABORATORIES
GREAT FALLS • BILLINGS MONTANA • BOISE IDAHO

Report of: Coal Analysis

Date August 17, 1976
Job Number 61-114-1
Sheet 1 of 1

Report to: BUREAU OF RECLAMATION (2)
316 North 26th Street
Room 2425 - Federal Building
Billings, Montana 59103

Sample Identification:

On July 8, 1976, this coal sample was delivered to our laboratory with instructions to perform the following analyses.

TEST RESULTS:

Sample #2

Area : Otter Creek East
Depth, Feet: 139.5 to 157.0
Lab No. : 62643

Analysis	Proximate	Ultimate		Sulfur Forms	
% Moisture:		% Carbon:		Pyritic Sulfur:	
As Received	28.15	As Received	49.12	As Received:	0.03
Air Dry Loss	10.01	Air Dry	54.59	Air Dry	0.03
Oven Dry Loss	20.16	Oven Dry	68.38	Oven Dry	0.04
% Ash:		% Hydrogen**:		Sulfate Sulfur:	
As Received	7.01	As Received	6.20	As Received	0.01
Air Dry	7.70	Air Dry	5.65	Air Dry	0.01
Oven Dry	9.75	Oven Dry	4.25	Oven Dry	0.01
% Volatile:		% Nitrogen:		Organic Sulfur:	
As Received	27.42	As Received	0.80	As Received	0.18
Air Dry	30.47	Air Dry	0.89	Air Dry	0.20
Oven Dry	38.16	Oven Dry	1.11	Oven Dry	0.25
% Fixed Carbon:		% Oxygen:**		Total Sulfur:	
As Received	37.42	As Received	36.65	As Received	0.22
Air Dry	41.58	Air Dry	30.84	Air Dry	0.24
Oven Dry	52.09	Oven Dry	16.21	Oven Dry	0.30
% Sulfur:					
As Received	0.22				
Air Dry	0.24				
Oven Dry	0.30				
BTU, per pound:					
As Received	8,351				
Air Dry	9,281				
Oven Dry	11,625				
BTU, per pound:					
Ash, moist free	12,881				

* *Includes coal moisture content in accordance with ASTM D3176.

Certified Larry D. O'Dell

NORTHERN TESTING LABORATORIES

GREAT FALLS • BILLINGS MONTANA • BOISE IDAHO

Report of: Coal Analysis

Date August 17, 1976
Job Number 61-114-1
Sheet 1 of 1

Report to: BUREAU OF RECLAMATION (2)
316 North 26th Street
Room 2425 - Federal Building
Billings, Montana 59103

Sample Identification:

On July 8, 1976, this coal sample was delivered to our laboratory with instructions to perform the following analyses.

TEST RESULTS:

Sample #3

Area : Otter Creek East
Depth, Feet: 210.0 to 227.3
Lab No. : 62444

Analysis	Proximate	Ultimate		Sulfur Forms	
% Moisture:		% Carbon:		Pyritic Sulfur:	
As Received	27.38	As Received	49.69	As Received:	0.02
Air Dry Loss	9.66	Air Dry	55.00	Air Dry	0.02
Oven Dry Loss	19.62	Oven Dry	68.42	Oven Dry	0.02
% Ash:		% Hydrogen**:		Sulfate Sulfur:	
As Received	6.58	As Received	6.26	As Received	0.01
Air Dry	7.28	Air Dry	5.74	Air Dry	0.01
Oven Dry	9.06	Oven Dry	4.41	Oven Dry	0.01
% Volatile:		% Nitrogen:		Organic Sulfur:	
As Received	27.88	As Received	0.86	As Received	0.36
Air Dry	30.86	Air Dry	0.95	Air Dry	0.40
Oven Dry	38.39	Oven Dry	1.18	Oven Dry	0.50
% Fixed Carbon:		% Oxygen: **		Total Sulfur:	
As Received	38.16	As Received	36.22	As Received	0.39
Air Dry	42.24	Air Dry	30.60	Air Dry	0.43
Oven Dry	52.55	Oven Dry	16.40	Oven Dry	0.53
% Sulfur:					
As Received	0.39				
Air Dry	0.43				
Oven Dry	0.53				
BTU, per pound:					
As Received	8,589				
Air Dry	9,507				
Oven Dry	11,828				
BTU, per pound:					
Ash, moist free	13,006				

**Includes coal moisture content in accordance with ASTM D3176.

Certified Larry L. O'Dell

LAND CLASSIFICATION

Land classification is a systematic appraisal of lands for a specific purpose. In this classification, lands were grouped in classes 1, 2, 3 or 6 based on their physical and chemical properties that related to their use for plant media in reclaiming surface-mined land. Specifications are on Table 5.

Description of the Land

The principal natural land bodies consist of alluvial soils of local origin, colluvial soils, and residual soils. Within each soil type there is a range of physical and chemical properties. Alluvial soils are the most uniform and residual soils are the most diverse. The principal land condition represented by each soil group is described separately.

Alluvial Soils

The alluvial soils in this site are on flood plains and terraces of small intermittent upland streams. Surface gradients range from 0 to 6 percent. The vegetative cover is largely mid and short grasses with scattered big sage and a few forbes.

Weakly developed loamy soil profiles are most common. This material is permeable, retains up to 2 inches of water per foot, is well-drained, and is relatively stable. Precipitation enters and moves through this soil readily; therefore, surface runoff and erosion are minimal. The vertical water movement has usually leached the soluble salts below 36 inches. Free carbonates occur just below the surface layer and the subhorizons are often saline and may be gypsiferous.

These soils are well suited for use as plant media. They occupy about 25 percent of the study site.

Colluvial Soils

The colluvial soils are on footslopes and fans in the upland. They have developed under a mid and short grass plant association that has a moderate amount of big sage and forbes. Slope gradients range from 4 to 15 percent.

Loamy and fine loamy soil profiles with moderate development are most common. The physical and chemical properties of the surface few inches are similar to the alluvial soils. The lower horizons and substrata have retained many of the physical and chemical properties of the parent material. This material is usually fine textured, slowly permeable and saline. It retains about 2 inches of available water per foot. Surface

LAND CLASSIFICATION SPECIFICATIONS - SURFACE MINE RECLAMATION
Suitability of Overburden for Revegetation of Surface-Mined Areas
BLM/HK Cooperative Program EMRIA
Otter Creek East Study Site

Table 5
United States
Dept. of the Interior
Bureau of Reclamation
July 1975

Overburden Characteristics	Symbols Basic Subclass	Symbols Inform. & Defic.	Class 1	Class 2	Class 3
SOILS AND/OR BEDROCK	s				
Textures			Sandy loams to clay loams.	Sandy loam to silty clay loams.	Loamy sand to clay.
Coarse		v		Sandy loams sufficiently coarse to slightly reduce productivity, moisture retention and may increase erosiveness slightly	Loamy sand in sufficient quantity to moderately reduce productivity and moisture retention, and may increase erosiveness moderately
Fine		h		Profile should have sufficient material for top dressing; clayey type materials that are moderataly permeable should be placed below 6" in the reconstructed profile.	Profile should have sufficient material for top dressing; placement of clay in reconstructed profile; permeable 10" plus; slowly permeable 30" plus.
Depth		d	36" of overburden that is suitable for plant media.	18" of overburden that is suitable for plant media.	10" of overburden that is suitable for plant media.
Sodicity		a	SAR not to exceed 9.0 in clay textured material but may be 20.0 in loam sand. Values may be higher if compensated by adequate gypsum.		
Salinity (EC x 10^3)		s	Overburden with characteristics (chemical and physical) capable of producing an expected electrical conductivity at equilibrium with the natural precipitation must be readily available as follows:		
			Less than 4	Less than 8 except the surface 10" must be < 4	Less than 12 except the surface 10" must be < 4
Available Water Holding Capacity		q	>1.5"/foot of overburden	>1.0"/foot of overburden	>.75"/foot of overburden
Hydraulic Conductivity		p	Adequate to provide a well drained and aerated root zone and an infiltration rate adequate to prevent serious erosion.	Slightly restricted; movement of drainage water and aeration in the lower root zone will be reduced. Infiltration rate may be reduced and erosion hazard increased slightly.	Restricted in the lower root zone and internal drainage may limit choice of plant species. Restricted infiltration may create serious but controllable erosion hazard.
Indurated Sandstone Stones and cobble		x	Permissible stone in overburden that may be stockpiled and reused as surface soil 0 to 10" < 5%	Permissible stone in overburden that may be stockpiled and reused as surface soil 0 to 10" <10%	Permissible stone in overburden that may be stockpiled and reused as surface soil 0 to 10" <20%
Weatherability 1/			Will break down readily upon exposure to the weather.	May require short period to break down upon exposure.	May require extended period to break down.
Erodibility		e	Slight	Moderate, controllable with average management.	Severe but controllable with above average management and selective placement of overburden.
TOPOGRAPHY 2/	t				
Slope		g	Permissible surface gradient g = 0 to 12 with smooth slopes	Permissible surface gradient g = 0 - 20%	Permissible surface gradient g = 0 - 35%.
Indurated Sandstone Massive and lenticular		r	None	1 to 5% of area.	5 to 20% of area.
Cover		c	Not applicable.		
DRAINAGE	d		'Present drainage conditions, surface and subsurface) are not a factor in this classification because of the anticipated land disturbance during mining. All soil properties evaluated to classify the land were also considered in evaluating material that may be placed in the subsurface drainage zone, but this evaluation did not affect the land classes.		
Class 6			Areas delineated in this class generally lack suitable material for stripping and stockpiling for surface use. One or a combination of the following deficiencies may result in the use of this class: (1) insufficient surface soil and bedrock of suitable quality at or near the surface; (2) topography which prevents general stripping and stockpiling; (3) rocklands with large amounts of massive indurated sandstone; (4) toxic overburden (soil and bedrock), on or near the surface. Reclamation of these lands will require material from outside the delineated area, from deep geologic strata, or special treatment of available material.		

1/ Applicable only to unweathered bedrock material.
2/ Not applicable to unweathered bedrock material.

runoff and erosion is in part slope dependent. In these land areas it ranges from low to moderate.

The upper 12 to 18 inches of soil are well suited for plant media. It may be placed at or near the surface of reconstructed profiles. Lower horizons are best suited for use below the surface layer.

Residual Soils

In this site the residual soils are on narrow ridges, knobs and steep and eroded slopes. The vegetative cover is variable and reflects the interaction of slowly permeable soils, slope gradient and the resultant erosion. Mid and short grasses are most common, but the number of forbes and salt-tolerant sedges and shrubs is high. Slope gradients range from 4 to over 35 percent. The rate of erosion is usually high.

Soil profile development is minimal and the physical and chemical properties below the surface 2 to 5 inches are similar to the underlying Fort Union ormation. This material is usually soft silty and clayey shales. This subsurface material is fine-textured, slowly permeable, commonly saline and sodic.

A composite of the surface 6 inches, the approximate minimum stripping depth, will be fair-to-good for use as plant media. Residual soils represent 65 percent of the site. Raw shale exposures and rock outcrops are included in this soil type.

Description of Classes

Class 1 land has no major soil and topographic limitations. Topographically, this land is well-suited for stripping and stockpiling suitable overburden for use as plant media. The physical and chemical properties of this material makes it suitable for use at or near the surface of reconstructed profiles. Land in this class is usually a good source of topdressing material. This material may be used in tracts with insufficient good-quality plant media.

Class 2 land has few soil and topographic limitations. Topographically this land can be stripped and stockpiled without special practices. The suitability of this material for use as plant media is reduced because of texture, permeability, salinity or quantity. Class 2 land has sufficient material for reclamation, but is only a fair-to-poor source of borrow material.

Class 3 land is limited by topography and soils and special measures such as selective stripping and borrowing topdressing material for localized tracts will be required. Most Class 3 land will have

sufficient suitable overburden for reclamation. However, the reclamation potential will be lower because of quantity, texture, permeability, salinity or sodicity. A high level of management will be required for optimum results.

Class 6 land does not have sufficient suitable overburden for reclamation. Material must be borrowed or the available material modified for optimum results. The topography and land conditions also limit stripping. Steep eroded slopes, bluff-forming sandstone and rock outcrops are common. However, selective stripping of the best material will reduce the amount of borrow required.

Methods and Procedures

The chemical and physical properties of soil profiles were evaluated in typical land areas and the land classes were delineated on photographs. Most profiles were sampled for testing in the soil laboratory. After the laboratory tests were completed, the land classes were finalized on reproducible drawings.

Standard laboratory procedures for pH, conductivity (salts), water movement, and soil stability were performed on all samples. Trace elements and heavy metals were determined on the bedrock cores.

Typical profile descriptions are recorded on Tables 7, 9, 11 and 13. Erosion conditions are shown on Tables 6, 8, 10 and 12. Tables 6-13 on pages 24-31.

Results of Classification

Class 1 land occurs on 38 percent of the study site. This material is of good quality and will be easily stripped and stockpiled. It is largely loamy texture.

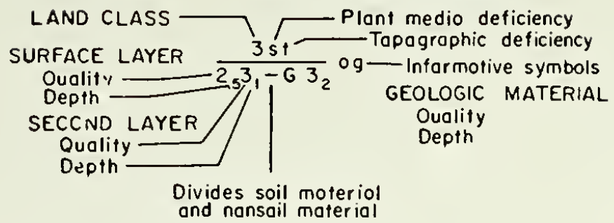
Class 2 land makes up only 16 percent of this site. The major soil deficiency is salinity and permeability. Sodium and rock are the other deficiencies.

Class 3 land occurs on 31 percent of the area. Soil deficiencies are sodicity, salinity and permeability. Some slick spots and rock and shale outcrops are included in this class. Some borrow will be required, but resurfacing material is adequate in most tracts.

Class 6 land represents 9 percent of the site. Small inclusions of good soil occur, but it is doubtful if they merit selective stripping.

The location and aerial distribution of the land classes are shown on Plate 4. This drawing also shows the soil and topographic deficiencies.

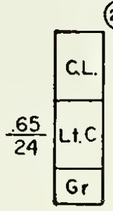
LAND CLASSIFICATION SYMBOLS



SOIL PROFILE NOTES

PROFILE REPRESENTS 5' DEPTH

(25) SOIL PROFILE NUMBER



2.8 EC mmhos/cm. Sat.Ext.
8.4 pH 1:5 Soil-Water Suspension
8.0 pH Soil - $CaCl_2$ Suspension
.65 Hydraulic Conductivity in./hr. (Disturbed Samples)
24 Settling Volume

INFORMATIVE SYMBOLS

OVERBURDEN DEFICIENCIES (For plant media)

- a Salinity
- s Sodicity
- h Clay (very fine texture)
- v Coorse (very sandy texture)
- p Restricted permeability
- q --- Available maisture copacity
- d Depth of suitable averburden
- x Staniness

TOPOGRAPHIC DEFICIENCIES

- g Slape (including grodient and complexity)
- r Massive lenticular sandstone and/ar Glacial cratics.
- c Cover

SOIL PROFILE SYMBOLS

Cb	Cobble
Gr	Gravel
S	Sand
LS	Loamy Sond
SL	Sandy Laam
L	Loom
SiL	Silt Loam
SCL	Sandy Clay Loom
CL	Clay Loam
SiCL	Silty Cloy Loam
SC	Sandy Clay
C	Clay
SiC	Silty Cloy
Sh	Shale
Ss	Sandstone
F	Fine
Lt	Light
M	Medium
H	Heavy

CONVENTIONAL AND SPECIAL MAP SYMBOLS

LAND FEATURES

- Blowout
- Cloy spot
- Gravelly spot
- Gumba, slick or scaby spot (sodic)
- Dumps ond similar nonsoil oreos
- Rock outcrop (includes shale ond sondstone)
- Baked rock - clinker (local name scario)
- Slide or slip (tips point upslope)
- Stony spot, very stony spot
- Greasewood

WATER FEATURES

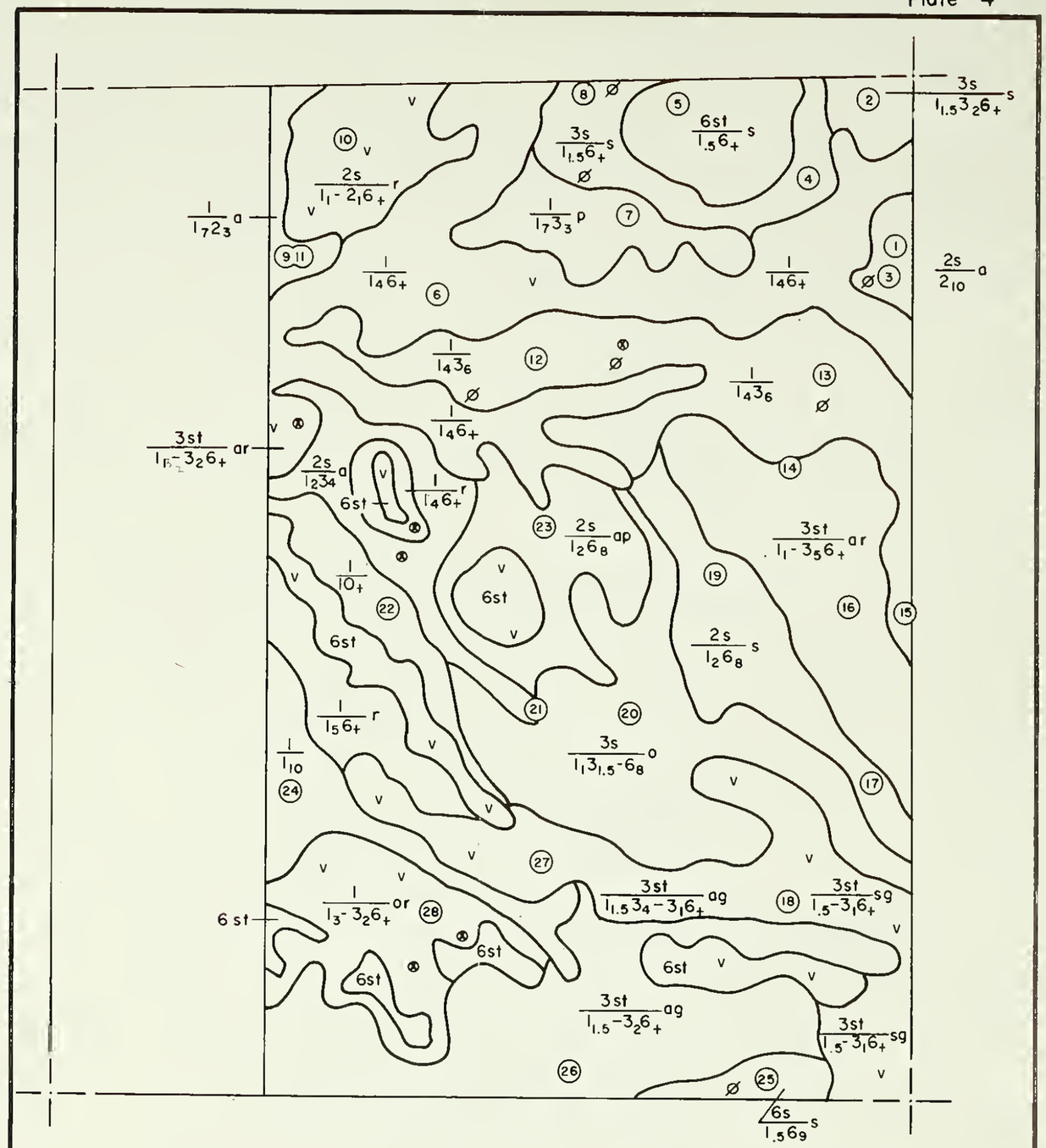
- Marsh or swamp
- Spring
- Well, artesian
- Well, irrigation
- Wet spot

PITS

- Gravel
- Mine

DAMS

- Medium or small



Section 26, T. 4 S.-R. 45 E.

1000 0 1000 2000

SCALE OF FEET

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

RESOURCE & POTENTIAL RECLAMATION EVALUATION

OTTER CREEK EAST SITE - OTTER CREEK MINI-SITE
OTTER CREEK COAL FIELD - MONT.

SEMI DETAIL LAND CLASSIFICATION

LANOS H B WARD — SUBMITTED
DRAWN L E ALLSOP — RECOMMENDED
CHECKED — APPROVED

BILLINGS, MONTANA — JANUARY, 1977

Results of the screenable tests in the soil laboratory are recorded on Table 14 in the back of this report. (See pages 32 through 49.)

Plate 5 shows the location of and the approximate depth of the usable material.

Soil Inventory

The Powder River Area soil survey was used as a base map, but the soil delineations were changed where the more detailed information obtained during this study indicated a change was warranted. The results of this work are shown on Plate 6.

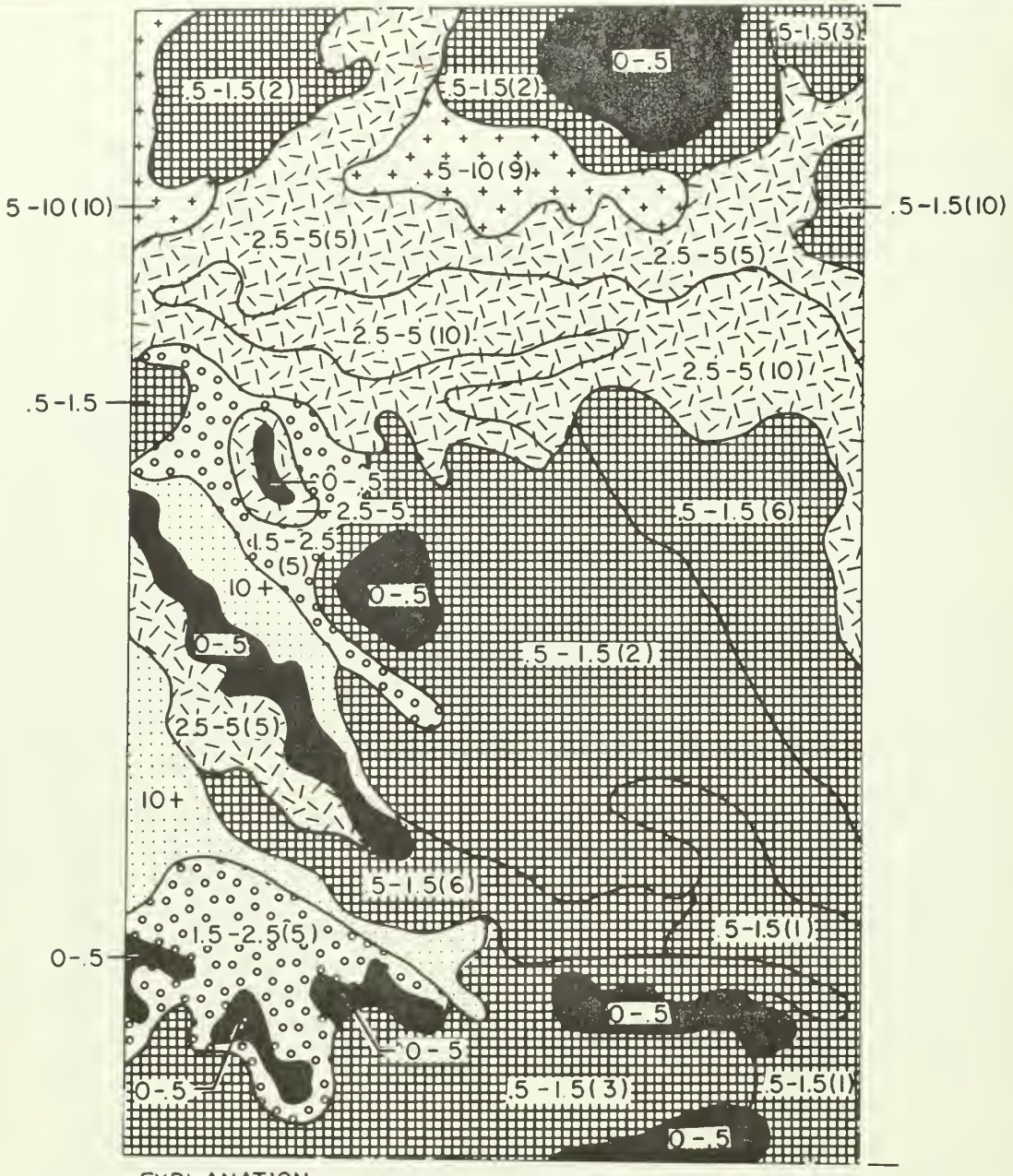
Reclamation Potential

The land conditions in this site are adequate for satisfactory reclamation of the land if the site is surface mined. The soil and topographic conditions are best suited for returning the site to range. Adding borrow material to class 6s and 6st tracts is necessary for satisfactory reclamation. However, profile enhancement and increased production under post-mining conditions are possible.

To achieve maximum or optimum productivity levels under post-mining conditions, the following measures should be considered and used where applicable. Add borrow material to some class 3s and 3st tracts. Class 6 land must receive additional topdressing material. The mining plan should provide for stripping and stockpiling suitable overburden for topdressing reshaped spoils. The quantity of this material would be determined by the post-mining goals of optimum or maximum productivity. Other measures that should be considered and used where applicable are slope reduction and reducing the number of moderately steep south and southwest facing slopes.

Regardless of the goal selected, the mining plan should also provide for the use of current approved land preparation and planting methods. Plant species, that are compatible with the land conditions, should be selected from an approved list.

A few relatively small tracts (10 to 40 acres) could be made suitable for small grain production in this site.



EXPLANATION

DEPTH OF USEABLE MATERIAL

MATERIAL FOR USE ON OR NEAR THE SURFACE

		ACRES
	0 - 0.5'	43.2
	0.5 - 1.5'	238 2
	1.5 - 2.5'	35.5
	2.5 - 5.0	122 0
	5.0 - 10.0'	17.9
	10.0' +	23.1

TOTAL DEPTH OF SUITABLE MATERIAL

(5) 1/

1/ Additional material over the amount indicated by the zip-a-tane symbols will require special placement. High salinity is camman.

Section 26, T. 4 S. - R. 45 E.

1000 0 1000 2000

SCALE OF FEET

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

RESOURCE & POTENTIAL RECLAMATION EVALUATION

OTTER CREEK EAST SITE - OTTER CREEK MINI SITE
OTTER CREEK COAL FIELD - MONT.

SUITABILITY OF MATERIAL FOR PLANT MEDIA

LANDS _____ SUBMITTED _____

DRAWN L E ALLSOP RECOMMENDED _____

CHECKED _____ APPROVED _____

BILLINGS, MONTANA JANUARY, 1977

Series

Slope $\frac{03}{D3N}$ Textural group

Erasian class

Series Number 9006 through 9040

SLOPE CLASS	EROSION CLASS
A 0- 3 Percent	1 ----- Stable
B 3- 7 Percent	2------ Slight
C 7-12 Percent	3--- Moderate
D 12-20 Percent	4----- Severe
E 20-35 Percent	5----- Critical
F 35-75 Percent	

TEXTURAL GROUP

- V { Sand, Loamy Sand } Coarse } Sandy
- I { Sandy Loam, Fine Sandy Loam } Moderately Coarse
- M { Very Fine Sandy Loam, Loam, Silt Loam } Medium
- N { Sandy Clay Loam, Clay Loam, Silty Clay Loam } Moderately Fine
- H { Sandy Clay, Silty Clay, Lt., M & H Clay } Fine } Clayey

(I, M, N, H } Loamy)

CONVENTIONAL AND SPECIAL MAP SYMBOLS

LAND FEATURES

- Blowout
- Clay spot
- Gravelly spot
- Gumba, slick or scaby spot (sadic)
- Dumps and similar nonsoil areas
- Rock outcrop (includes shale and sandstone)
- Baked rock - clinker (local name scoria)
- Slide or slip (tips point upslope)
- Stony spot, very stony spot
- Greasewood

WATER FEATURES

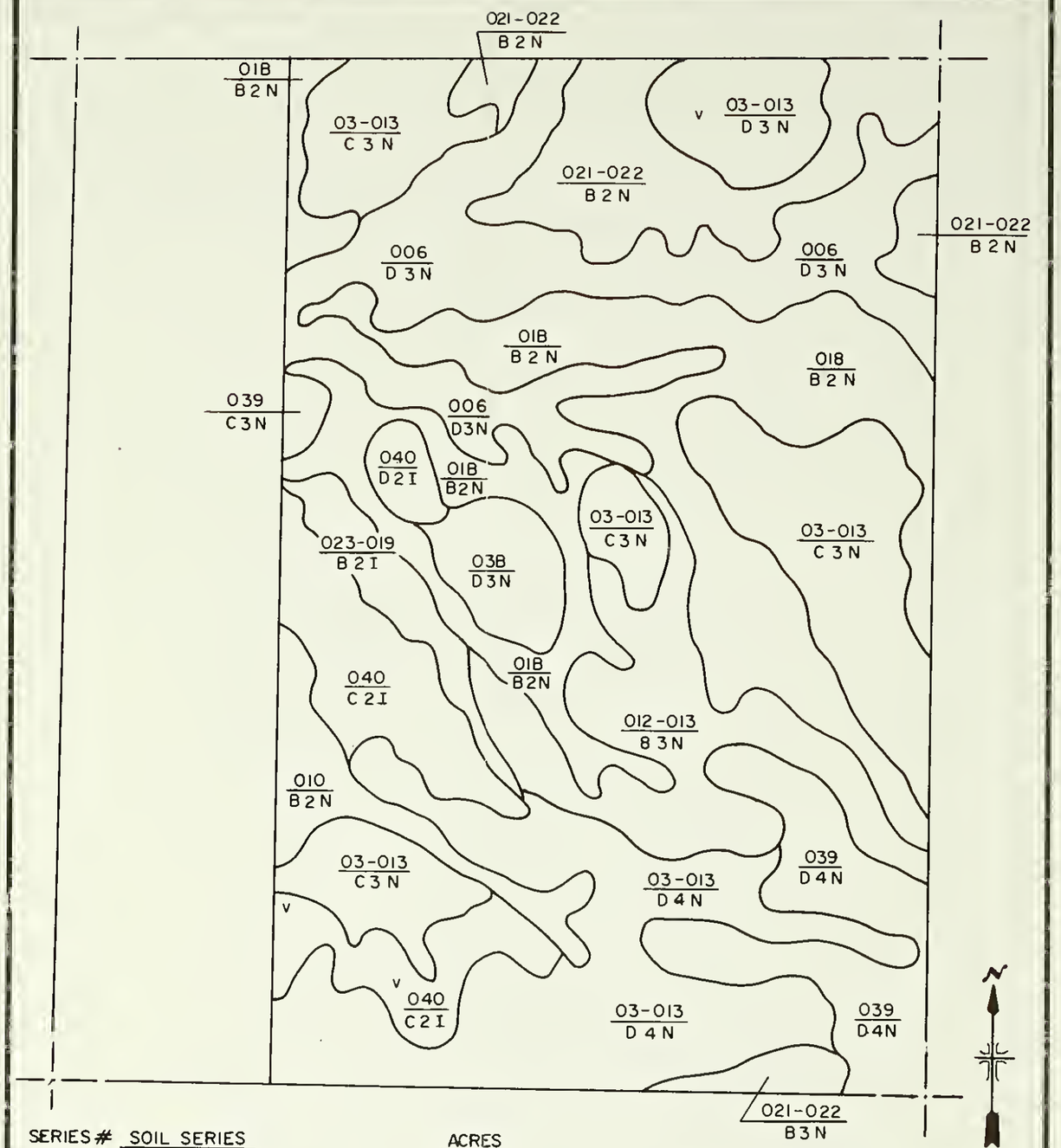
- Marsh or swamp
- Spring
- Well, artesian
- Well, irrigation
- Wet spot

PITS

- Gravel
- Mine

DAMS

- Medium or small



SERIES #	SOIL SERIES			ACRES
021-022	Ab	Arvada - Bane	0-4 %	42.5
012-013	Ce	Cushman - Elso	4-8 %	31.9
010	Hk	Heldt	2-4 %	13.8
018	Hu	Hydra	2-4 %	88.5
03-013	Mg	Midway - Elsa	8-35%	153.7
038	Mr	Midway - Rockland	15-35 %	9.2
039	Mw	Midway - Elsa - rocky	35-75%	29.0
006	Te	Terrace Escarpment	8-35%	65.1
023-019	Vr	Vana - Remmit FSL	4-8 %	7.4
040	Oc	Ocean Lake - Rockland	15-45 %	38.9

NOTE

Montana State Number 9006-9040

Map Number 006-040

Section 26, T. 4 S. - R. 45 E.

1000 0 1000 2000

SCALE OF FEET

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

RESOURCE & POTENTIAL RECLAMATION EVALUATION

OTTER CREEK EAST SITE - OTTER CREEK MINI-SITE
OTTER CREEK COAL FIELD - MONT.

SOILS MAP

LANDS H B WARD SUBMITTED

DRAWN L E ALLSOP RECOMMENDED

CHECKED APPROVED

BILLINGS, MONTANA JANUARY, 1977

Form 7310–12
(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

By | Date

Location

Treatment affecting the **SSF**

Table 6

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 (5)	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil **exposed** over much of area, **may have** embryonic dunes and wind **scoured** depressions 12 **13** 14
SURFACE LITTER*	Accumulating in place 0 1 2 (3)	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little **remaining** *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water 0 1 (2)	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, **surface** rock or fragments **are dissected** by rills and gullies **or are** already washed **away** 12 **13** 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 (3)	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most **rocks and** plants pedestalled **and roots** exposed 12 **13** 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 (3)	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow **patterns are** numerous and readily **noticeable**. May **have** large **barren fan** deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 (3)	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be **present** at 3" to 6" deep at **intervals less** than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 (3)	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of **the area** and over 50% are actively eroding 13 14 15

SITUATION	TOTAL				

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

Bone Series

U S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

VEGETATION–SOIL DESCRIPTION

1. State	2. District	3. Planning Unit	4. Vegetation–Soil Unit	5. Soil Map Symbol	6. Surname	7. Date
Mont	--	--	---------- / 7022	622	----------	6 mo 76 yr

8. Area	9. County	10. Location	11. Photo No.	12. Writeup No.	13. File No.	14. Parent Rock
--	P. River	(3) Sec. --, T. 45 --, R. 5 --	BZN ----------	----	------	Shale

15. Formation Name	16. Surface Conditions (percent)	17. Land Conditions	18. Landform
Fort Union	Stone -- Rock --	Alkaline ✓ Saline ✓ Water table —	Alluvial

19. Slope (percent)	20. Aspect	21. Elevation	22. Present Erosion	23. Hydrologic Group
2-4% ☐ Single ☑ Complex	N	3152	Type SSF --- Class –	–

24. Precipitation (in)	25. Temperature	26. Frost-free	27. Drainage Class	28. Infiltration	29. Percolation	30. ERD	31. AWC
12-16" 1st ✓, 2nd ✓, 3rd , 4th	-- Air -- Soil ✓	Days ---> 28° —	Mod. Well Drained	Moderate	Moderate	-- in	--.-- in per ft

32. HORIZON	33. THICKNESS	34. COLOR DRY / MOIST — MATRIX	34. COLOR DRY / MOIST — MOTTLING	35. TEXTURE	36. STRUCTURE	37. CONSISTENCY DRY MOIST	38. CLAY FILMS	39. ROOTS	40. STONES % VOL.	41. REACTION (pH)	42. BOUNDARY
A2	0-.5	(D) 10YR 7/2 (M) 10YR 5/3	—	FSL	c 1 pl / c 2 gr.	(D) sh (M) fr	—	2 f	—	0	a
B2t	.5-3"	(D) 10YR 5/3 (M) 10YR 4/3	—	CL	c 2 cpr / 2 m bk	(D) h (M) fi	1 mpf	2 f	—	ve	g
Cca	3-18"	(D) 10YR 6/3 (M) 10YR 5/3	—	CL	c 1 bkl m bk	(D) h (M) fr	—	2 f	—	e	g
C2	18-30	(D) 10YR 6/3 (M) 10YR 5/3	—	SiCL	massive	(D) h (M) fr	—	1 f	—	es	g
C3	30-54	(D) 10YR 6/4 (M) 10YR 5/4	—	SiCL	↓	(D) h (M) fr	—	—	—	es	g
4	54-66	(D) 10YR 6/6 (M) 10YR 5/4	—	FSL		(D) sh (M) s	—	—	—	es	g
	66-96	(D) 10YR 6/3 (M) 10YR 5/3	—	SiCL		(D) h (M) fr	—	—	—	es	g
	96-120	"	—	SiCL		(D) vh (M) fi	—	—	—	es	g

- Salt crystals through-out profile
- Thick spot surface
- Use barren with scattered Wildhorse

25

Table 7

Form 7310–12
(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

By | Date

Location

Treatment affecting the SSF

Table 8

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT *	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER *	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use on non-productive sites)* 12 13 14
SURFACE ROCK *	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit some movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING *	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS *	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15

SITUATION	TOTAL				

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

VEGETATION–SOIL DESCRIPTION

1. State	2. District	3. Planning Unit	4. Vegetation–Soil Unit	5. Soil Map Symbol	6. Surname	7. Date
Mont.	--	--	----------/7021	021 BZN	----------	6 mo 76 yr

8. Area	9. County	10. Location	11. Photo No.	12. Writeup No.	13. File No.	14. Parent Rock
--	P. River	(7) Sec. 26, T. 45, R. 5	----------	----	------	Shale

15. Formation Name	16. Surface Conditions (percent)	17. Land Conditions	18. Landform
Fort Union	Stone -- Rock --	Alkaline — Saline — Water table —	Alluvial

19. Slope (percent)	20. Aspect	21. Elevation	22. Present Erosion	23. Hydrologic Group
0-2 ☐ Single ☑ Complex	W	3142	Type SSF --- Class -	-

24. Precipitation (in)	25. Temperature	26. Frost-free	27. Drainage Class	28. Infiltration	29. Percolation	30. ERD	31. AWC
1st ✓, 2nd ✓, 3rd , 4th	-- Air -- Soil	Days ---> 28°	Mod. Well-Well	Moderate	Moderate	-- in	.12 in per ft

32. HORIZON	33. THICKNESS	34. COLOR DRY / MOIST — MATRIX	34. COLOR DRY / MOIST — MOTTLING	35. TEXTURE	36. STRUCTURE	37. CONSISTENCY DRY MOIST	38. CLAY FILMS	39. ROOTS	40. STONES % VOL.	41. REACTION (pH)	42. BOUNDARY
A2	0-1.5	(D) 10YR 6/2 (M) 10YR 5/2	—	L	c2pl/f1bk	(D) sh (M) vfr	—	2f	—	—	a
B21t	1.5-5	(D) 10YR 6/2 (M) 10YR 4/2	—	CL	m2pr/m2bk	(D) h (M) fr	1mpf	2f	—	—	g
B22t	5-10	(D) 10YR 5/2 (M) 10YR 4/2	—	SiCL	c1cpr/2mbk	(D) h (M) fr	2mpf	2f	—		g
B3	10-18	(D) 10YR 6/3 (M) 10YR 5/3	—	SiCL	c1pr/2mmbk	(D) h (M) fr	—	2f	—	e	g
Cca	18-24	(D) 10YR 6/3 (M) 10YR 5/3	—	L	c1bk/1mbk	(D) sh (M) vfr	—	1f	—	e	g
C2	24-48	(D) 10YR 7/3 (M) 10YR 6/3	—	FSL	Massive/1mbk	(D) sh (M) vfr	—	1f	—	es	a
5	48-60	(D) 10YR 7/3 (M) 10YR 6/3	—	LFS	↓	(D) sh (M) lo	—	--	—	es	a
4	60-90	(D) 10YR 6/3 (M) 10YR 5/3	—	L	↓	(D) sh (M) fr	—	—	—	es	a
5	90-120	(D) 10YR 6/3 (M) 10YR 5/3	—	SiL	↓	(D) h (M) fr	—	—	—	es	g

- Degraded saloncty area., 0-5" old Ap., 5"+ old or former cap area., no wideres of salt crystals. Surface grassed in slick spot area.
- Vegetation: W Wheat, N Thread, j. Grass, Downy Brome, scattered forbes & g. rushes.

Table 9

(Instructions inside back cover)

Form 7310–9 (December 1970)

Form 7310-12
(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

By	Date
Location	
Treatment affecting the SSF	

Table 10

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT *	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER *	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining (less cover on low productive sites) 12 13 14
SURFACE ROCK *	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING *	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS *	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15
SITUATION	TOTAL				

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Midway Series

VEGETATION–SOIL DESCRIPTION

1. State	2. District	3. Planning Unit	4. Vegetation–Soil Unit	5. Soil Map Symbol	6. Surname	7. Date
Mont	--	--	----------/9003	63 C3M	----------	4 mo 76 yr

8. Area	9. County	10. Location	11. Photo No.	12. Writeup No.	13. File No.	14. Parent Rock
--	R River	(16) Sec. 36, T. 45, R. 5	----------	----	------	Shale

15. Formation Name	16. Surface Conditions (percent)	17. Land Conditions	18. Landform
Fort Union	Stone -- Rock --	Alkaline — Saline — Water table —	Residual

19. Slope (percent)	20. Aspect	21. Elevation	22. Present Erosion	23. Hydrologic Group
4-8% ☐ Single ☑ Complex	W	3220	— Type — SSF --- Class –	–

24. Precipitation (in)	25. Temperature	26. Frost-free	27. Drainage Class	28. Infiltration	29. Percolation	30. ERD	31. AWC
1st ✓, 2nd ✓, 3rd , 4th –	-- Air -- Soil	Days --- > 28°	Mod. well Drained	Moderate	Moderate	-- in	2.2 in/ft.

32. HORIZON	33. THICKNESS	34. COLOR DRY / MOIST — MATRIX	34. COLOR DRY / MOIST — MOTTLING	35. TEXTURE	36. STRUCTURE	37. CONSISTENCY DRY MOIST	38. CLAY FILMS	39. ROOTS	40. STONES % VOL.	41. REACTION (pH)	42. BOUNDARY
A2	0-1"	(D) 10YR 6/2 (M) 5/2		CL	c1pl/f1bk	(D) sh (M) fr	–	2f	–	–	g
AB	1-4"	(D) 10YR 6/3 (M) 4/2		CL	c1bk/m2bk	(D) h (M) fr	–	2f	–	–	g
B2t	4-7"	(D) 10YR 6/4 (M) 5/3		SiCL	c1pr/m2bk	(D) h (M) fi	1npf	2f	–	–	g
B3ca	7-12"	(D) 7.5YR 5/5 (M) 7.5YR 5/4	(Shale influence)	SiCL	c1pr/m2bk	(D) h (M) fi	–	2f	–	e	a
Cca	12-18"	(D) 10YR 6/3 (M) 10YR 5/3		SiCL	vc1bk/c1bk	(D) h (M) fr	–	1f	–	es	a
CR	18-42	(D) 10YR 7/2 (M) 10YR 6/3		SCL	–	(D) vh (M) efi	–	–	–	es	a
	42-60	(D) 10YR 7/4 (M) 10YR 5/6		SCL	–	(D) vh (M) efi	–	–	–	es	a
	60-72	(D) 10YR 7/3 (M) 10YR 6/6		CL	–	(D) vh (M) efi	–	–	–	es	a
R	72"+	—	—	—	—	—	—	—	—	—	

- Lime netting @ 12-18"
- SCL with high percent of silts -
- 60% canopy vegetated
- W. Wheat, N. Thread, B. Grama, Juncus, Gaya, Dandelion, Sagebrush

29

Table 11

(Instructions inside back cover)

Form 7310–9 (December 1970)

Form 7310–12
(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

By | Date 6/76

Location (22) 26..45..4

Treatment affecting the SSF

Table 12

DETERMINATION OF EROSION CONDITION CLASS

Sandy site

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT *	No visual evidence of movement 0 1 2 **(3)**	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER *	Accumulating in place 0 1 2 **(3)**	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining (rare on productive sites) 12 13 14
SURFACE ROCK *	If present, the distribution of fragments show no movement caused by wind or water 0 1 **(2)**	If present coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING *	No visual evidence of pedestalling 0 1 2 **(3)**	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS *	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence **(4)** 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits 13 14 15
RILLS	No visual evidence of rills 0 1 2 **(3)**	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes **(0)** 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15

SITUATION	TOTAL				

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

30

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

VEGETATION–SOIL DESCRIPTION

1. State	2. District	3. Planning Unit	4. Vegetation–Soil Unit	5. Soil Map Symbol	6. Surname	7. Date
Utah	– –	– –	– – – – – – – – – – / 9019	019 021	– – – – – – – – – – – – – – – – – –	– 5 mo 76 yr

8. Area	9. County	10. Location	11. Photo No.	12. Writeup No.	13. File No.	14. Parent Rock
– –	P. River	(NW) Sec. – – –, T. 45 –, R. 5 – –	– – – – – – – – – –	– – – –	– – – – – –	Sandstone

15. Formation Name	16. Surface Conditions (percent)	17. Land Conditions	18. Landform
Fort Union	Stone – – Rock – –	Alkaline — Saline — Water table —	Colluvial

19. Slope (percent)	20. Aspect	21. Elevation	22. Present Erosion	23. Hydrologic Group
– – 4-6% ☐ Single ☑ Complex	– NE – – – –	– 3170 – – – –	Type SSF – – – Class –	–

24. Precipitation (in)	25. Temperature	26. Frost-free	27. Drainage Class	28. Infiltration	29. Percolation	30. ERD	31. AWC
12-16" 1st ✓, 2nd ✓, 3rd , 4th	– – Air – – Soil	Days – – – > 28°	Well Drained	Mod Rapid	Mod Rapid	– – in	– .1-.2 in per ft

32. HORIZON	33. THICKNESS	34. COLOR DRY / MOIST — MATRIX	34. COLOR DRY / MOIST — MOTTLING	35. TEXTURE	36. STRUCTURE	37. CONSISTENCY DRY MOIST	38. CLAY FILMS	39. ROOTS	40. STONES % VOL	41. REACTION (pH)	42. BOUNDARY
A	0-3"	(D) 10YR 5/3 (M) 10YR 4/2	—	FSL	m 1 bk / f 1 bk	(D) so (M) lo	—	2f	—	—	g
B_2	3-9"	(D) 10YR 5/2 (M) 10YR 4/2	—	FSL	m 2 pr 1 / m 2 bk	(D) sh (M) fr	—	2f	—	e	g
B_{3ca}	9-15"	(D) 10YR 6/3 (M) 10YR 4/3	—	FSL	c 1 pl / m 1 bk	(D) so (M) lo	—	2f	—	ev	g
Cca	15-30	(D) 10YR 6/3 (M) 10YR 5/3	—	< FSL	vc 1 bk / c 1 bk	(D) so (M) lo	—	1f	—	ev	g
C_2	30-120	(D) 10YR 7/4 (M) 10YR 6/4	—	< FSL	Massive	(D) so (M) lo	—	—	—	ev	a

- Profile located [illegible] side slope [illegible] sandstone crest
- Vegetation - D Brome, N Thread, B Grama, [illegible] cactus, w. fat

31

Table 13

(Instructions inside back cover)

Form 7310–9 (December 1970)

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT Otter Creek East PROJECT _____

SOIL SCIENTIST Fiecht1 LOCATION- SECTION 26 T. 45 R. 45E DATE 6-1-76

LAB NO.	PROFILE NO.	DEPTH INCHES	TEXTURE		pH		SET. VOL. ml	EC		FRAG. HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE			HCL	%
			FIELD	LAB	1-5	$CaCl_2$		1-5	SAT. EXT.	8 hr in./hr.	24 hr in./hr.	TSC me/l	Cat Mg. me/l	SAR		SAND	SILT	CLAY		
T207	1	0-12	CL		7.6		24	.75 .10		1.04	1.08								—	
208		12-24	"		8.1		22	1.0 .13		1.16	1.12								+	
209		24-48	FSL		8.6	7.8	20	1.0 .13		1.32	1.16								++	
210		48-60	"		9.1	7.9	20	1.4 .18		1.40	1.28								++	
211		60-78	"		9.2	8.0	21	3.6 .47		.56	.60								++	
212		78-96	SCL		9.1	8.0	21	7.3 1.1	9.0	.12	.10	90.0	38.0	11.9	-2.8				++	
213		96-120	"		8.6	7.6	20	7.8 1.2	10.0	.21	.18								++	
214	2	0-18	CL		8.7	7.6	26	2.4 .30		.36	.38								++	
215		18-42	"		8.8	8.3	24	14.0 2.8	18.0	.20	.18	180.0	109.5	9.5					++	
216		42-60	SiCL		9.1	8.7	30	13.0 2.6	16.0	.0	.0	160.0	72.5	14.5					++	
217		60-84	"		9.1	8.6	36	11.0 2.0	14.0	.0	.0								++	
218		84-108	"		9.1	8.6	53	10.5 1.9	13.0	.0	.0	130.0	55.5	14.1					++	
219		108-120	"		8.9	8.3	40	10.0 1.8	13.0	.19	.22	130.0	57.5	13.5	-1.2				++	

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT Otter Creek East PROJECT

SOIL SCIENTIST Fiecht/ LOCATION - SECTION 26 T. 45 R. 25E DATE 6-1-76

LAB NO.	PROFILE NO.	DEPTH INCHES	TEXTURE		pH		SET. VOL. ml	EC		FRAG. HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE			HCL	%
			FIELD	LAB	1-5	$CaCl_2$		1-5	SAT. EXT.	8 hr in./hr.	24 hr. in./hr.	TSC me/l	Cat.Mg. me/l	SAR		SAND	SILT	CLAY		
T220	3	0-18	CL		8.2		24	10.0 1.8	8.5	.52	.60								+	
221		18-30	SiCL		8.5		26	10.0 1.8	10.0	.30	.32								++	
222		30-54	"		8.5		25	10.5 1.9	12.0	.56	.60								++	
223		54-66	FSL		8.6	8.0	25	7.4 1.1	9.0	.92	.88								++	
224		66-96	SiCL		8.6	8.0	34	8.0 1.3	8.0	.64	.64								++	
225		96-120	"		8.4		34	9.8 1.7	9.0	.30	.28								++	
226	4	0-6	CL		8.6	7.7	26	1.4 .18		.40	.52								—	
227		6-18	SiC	Lt.C	9.2	7.9	30	1.5 .19	1.35	.0	Tr.	13.5	2.8	9.0		24	33	43	++	
228		18-30	CL		8.7	8.0	25	9.4 1.6	9.0	.18	.16	90.0	44.0	9.8					++	
229		30-48	"		8.4		26	11.0 2.0	10.0	.32	.28								++	
230		48-72	"		8.9	8.0	45	6.3 .90	5.5	.0	Tr.	55.0	16.4	13.5	-0.4				++	
231		72-96	"		9.2	8.1	65	4.8 .65	4.5	.0	.0	45.0	7.2	19.9					++	
232		96-120	"		9.2	8.1	70	4.4 .58	5.0	.0	.0								11	

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT Otter Creek East PROJECT

SOIL SCIENTIST Fiechtl LOCATION - SECTION 26 T. 4S R. 45E DATE 6-1-76

LAB NO.	PROFILE NO.	DEPTH INCHES	TEXTURE		pH		SET. VOL. ml	EC		FRAG. HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE			HCL	%
			FIELD	LAB	1-5	$CaCl_2$		1-5	SAT. EXT.	8 hr in./hr.	24 hr in./hr.	TSC me/l	Cat.Mg. me/l	SAR		SAND	SILT	CLAY		
T233	5	0-6	SCL		8.8	8.2	33	9.5 1.7	16.0	.40	.48	160.0	50.0	22.0					++	
234		6-18	SiCL		8.9	8.4	48	12.5 2.2	19.0	.0	.08	190.0	66.0	21.6	-2.0				++	
235		18-36	CL		9.4	8.6	150	8.8 1.4	10.0	.0	.0	100.0	21.0	24.4					++	
236		36-48	"		9.6	8.7	200	9.0 1.5	5.0	.0	.0								++	
237		48-60	SiCL		9.4	8.6	90	13.0 2.6	8.4	.0	.0								++	
238	6	0-6	FSL		8.4		22	.75 .10		2.08	2.16								+	
239		6-24	Gr. FSL		8.5		20	.75 .10		3.60	3.40								+	
240		24-36	v.gr. FSL		8.6	7.7	20	.75 .10		1.52	1.60								+	
241		36-48	gr. FSL		8.6	7.7	18	1.0 .13		1.56	1.56								+	

Table 14
Sheet 3 of 18

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT Otter Creek East PROJECT _____

SOIL SCIENTIST Fiecht1 LOCATION - SECTION 26 T. 45 R. 45E DATE 6-1-76

LAB NO.	PROFILE NO.	DEPTH INCHES	TEXTURE		pH		SET. VOL. ml	EC		FRAG. HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE			HCL	%
			FIELD	LAB	1-5	$CaCl_2$		1-5	SAT. EXT.	8 hr. in./hr.	24 hr. in./hr.	TSC me/l	Cat. Mg. me/l	SAR		SAND	SILT	CLAY		
TR42	7	0-6	SiCL		7.8		25	.75 .10		1.40	1.60								—	
243		6-18	"		7.9		25	.75 .10		.84	.80								++	
244		18-24	L		8.5		22	.75 .10		.96	.96								+++	
245		24-48	FSL		8.5		20	1.0 .13		1.40	1.32								+++	
246		48-60	L-FS		8.8	7.4	19	1.2 .16		1.32	1.28								++	
247		60-90	FSL		8.8	7.6	20	2.2 .28		.72	.76								++	
248		90-108	L	CL	8.7	7.8	25	3.6 .46	3.3	.05	.06	33.0	7.6	13.0		27	40	33	++	
249		108-120	SiL		8.6	7.8	22	4.2 .55	4.0	.06	.06								++	
																	6-2-76			
250	8	0-12	SiCL		8.5		22	1.0 .13		1.52	1.60								++	
251		12-24	"	CL	9.4	8.2	60	3.4 .44	2.5	.0	.0	25.0	3.8	15.4		33	34	33	+++	
252		24-48	"		9.1	8.4	37	10.0 1.8	12.0	.09	.07	120.0	43.0	16.6					++	
253		48-72	"		9.1	8.0	80	7.6 1.25	7.5	.0	.0	75.0	23.0	15.3					++	
254		72-84	CL		8.8	8.2	70	7.6 1.25	9.0	.0	.0								++	
255		84-108	SiCL		8.8	8.2	90	7.2 1.1	7.0	.0	.0								++	
256		108-120	"		8.8	8.1	80	5.8 .80	7.0	.0	.0								+	

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT Otter Creek East PROJECT _____

SOIL SCIENTIST Fiechtl LOCATION - SECTION 26 T. 4S R. 45E DATE 6-2-76

LAB NO.	PROFILE NO.	DEPTH INCHES	TEXTURE		pH		SET. VOL. ml	EC		FRAG. HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE			HCL	%
			FIELD	LAB	1-5	$CaCl_2$		1-5	SAT. EXT.	8 hr in./hr.	24 hr in./hr.	TSC me/l	Cat.Mg. me/l	SAR		SAND	SILT	CLAY		
T257	9	0-12	CL		8.2		24	.75 .10		1.00	.96								Tr.	
258		12-24	L		8.9	7.8	21	.75 .10		.72	.76								++	
259		24-48	FSL		9.2	8.0	20	1.2 .16		.92	.92								++	
260		48-72	LFS		9.4	7.9	18	1.4 .18		1.32	1.20								++	=
261		72-96	FSL		9.0	7.9	19	2.6 .32		1.08	1.12								++	
262		96-120	L		8.7	7.7	19	3.6 .96		.92	.96								++	
263	10	0-6	SiCL		8.8	7.6	25	1.0 .13		.52	.48								++	
264		6-24	"		8.7	7.8	40	5.0 .68	4.7	.24	.28								++	
265	11	0-12	L		7.8		21	.75 .10		1.68	1.80								++	
266		12-36	"		8.5		19	1.0 .13		1.64	1.72								++	
267		36-66	FSL		9.2	8.0	21	1.6 .20		1.40	1.40								++	
268		66-84	L		9.1	8.0	22	3.5 .44		.48	.56								++	
269		84-108	"		8.7	8.0	20	6.0 .85	6.5	1.32	1.36								++	
270		108-120	FSL		8.7	8.0	20	5.4 .75	7.0	2.08	1.96								++	

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT Otter Creek East PROJECT

SOIL SCIENTIST Fiecht1 LOCATION- SECTION 26 T. 4S R. 45E DATE 6-2-76

LAB NO.	PROFILE NO.	DEPTH INCHES	TEXTURE		pH		SET. VOL. ml	EC		FRAG. HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE			HCL	%
			FIELD	LAB	1-5	$CaCl_2$		1-5	SAT. EXT.	8 hr. in./hr.	24 hr in./hr.	TSC me/l	Cat.Mg. me/l	SAR		SAND	SILT	CLAY		
T271	12	0-6	FSL		8.0		24	.75 .10		1.44	1.60								—	
272		6-18	CL		8.0		25	.75 .10		1.60	1.60								++	
273		18-30	FSL		8.6	7.8	20	1.0 .13		1.52	1.60								++	
274		30-48	LFS		8.9	7.8	17	1.0 .13		1.68	1.68								++	
275	13	0-6	CL		7.7		24	.75 .10		1.00	1.00								—	
276		6-18	SiCL		7.7		25	.75 .10		.68	.60								++	
277		18-30	"		8.6	7.3	24	1.4 .18		.76	.80								+++	
278		30-48	"		9.3	8.0	31	2.2 .28	1.5	.28	.32	15.0	3.8	8.1					++	
279		48-66	"	CL	9.4	8.1	40	3.8 .47	2.1	.05	.03	21.0	4.0	12.0	even	31	38	31	++	
280		66-84	L		9.1	8.1	26	5.0 .68	4.7	.16	.14								++	
281		84-102	SCL		9.0	8.1	23	5.8 .80	6.5	.52	.56								++	
282		102-120	"		8.8	8.0	20	5.0 6.8	6.0	1.36	1.36								++	

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT Otter Creek East PROJECT

SOIL SCIENTIST Fiechtl LOCATION - SECTION 26 T. 9S R. 45E DATE 6-2-76

LAB NO.	PROFILE NO.	DEPTH INCHES	TEXTURE		pH		SET. VOL. ml	EC		FRAG. HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE			HCL	%
			FIELD	LAB	1-5	$CaCl_2$		1-5	SAT. EXT.	8 hr in./hr.	24 hr in./hr.	TSC me/l	Cat.Mg. me/l	SAR		SAND	SILT	CLAY		
T283	14	0-24	SiL	L	8.5		22	1.0 .13		1.98	1.48					38	43	19	H	
284			"		8.8	8.2	20	6.0 .85	6.5	.72	.72								H	
285			L		8.8	8.2	24	5.8 .80	6.5	.23	.23								H	
286	15	0-12	SiCL		8.0		27	.75 .10		.94	.38								—	
287		12-30	"		8.5		24	1.0 .13		1.12	1.12								H	
288		30-48	SCL		9.0	8.1	21	1.3 .16		2.80	2.80								H	
289		48-60	SiCL	Hv. L	9.2	8.0	27	2.0 .25	1.75	.22	.22	17.5	2.4	13.8		45	32	23	H	
290		60-72	"	Hv. CL	9.1	8.0	32	2.8 .34	2.0	.03	.03	20.0	3.0	13.9	-0.8	33	28	39	H	
291		72-96	"		9.2	8.2	32	3.6 .47		.05	.09								H	
292		96-120	Lt. SiCL		9.2	8.0	25	3.9 .43		.20	.18								H	

Table 14
Sheet 7 of 18

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT Otter Creek East PROJECT

SOIL SCIENTIST Fiecht1 LOCATION - SECTION 26 T. 45 R. 45E DATE 6-3-76

LAB NO.	PROFILE NO.	DEPTH INCHES	TEXTURE		pH		SET. VOL. ml	EC		FRAG. HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE			HCL	%
			FIELD	LAB	1-5	$CaCl_2$		1-5	SAT. EXT.	8 hr in./hr.	24 hr in./hr.	TSC me/l	Cat. Mg. me/l	SAR		SAND	SILT	CLAY		
T293	16	0-6	CL		8.3		26	.90 .12		1.52	1.60								+	
294		6-18	SiCL	Lt. C.	9.0	8.1	45	3.2 .90	2.8	.06	.07	280	5.6	13.4	even	18	31	51	++	
295		18-42	FSCL		8.8	8.2	32	10.0 1.8	12.0	.80	.84								++	
296		42-60	"		8.8	8.3	35	11.0 2.0	13.0	.72	.76								++	
297		60-72	CL		8.8	8.3	45	9.4 1.6	11.0	.30	.34								++	
T298	17	0-12	CL		8.5		24	1.0 .13		1.42	1.32								+	
299		12-36	SiCL		8.5		27	12.5 2.4	14.0	.48	.52								++	
300		36-48	"		8.7	8.4	25	14.0 2.9	16.0	.52	.56								++	
301		48-66	"		8.5		29	13.0 2.6	14.0	.34	.40								++	
302		66-78	SiC		8.0		40	14.0 2.9	14.0	.10	.12	140.0	70.0	11.8					—	
303		78-96	carb. sh.		5.9	5.4	30	13.5 2.7		2.96	3.04									
Not sampled		96-120	coal																	

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT Otter Creek East PROJECT

SOIL SCIENTIST Fiechtl LOCATION - SECTION 26 T. 45 R. 45E DATE 6-3-76

LAB NO.	PROFILE NO.	DEPTH INCHES	TEXTURE		pH		SET. VOL. ml	EC		FRAG. HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE			HCL	%
			FIELD	LAB	1-5	$CaCl_2$		1-5	SAT. EXT.	8 hr. in./hr.	24 hr in./hr.	TSC me/l	Cat.Mg. me/l	SAR		SAND	SILT	CLAY		
T304	18	0-6	SiCL		8.7	7.4	25	1.0 .13		.30	.30								+	
305		6-18	"		8.1		38	8.6 1.9	7.5	.48	.52								+	
306		18-30	"		8.5		90	7.4 1.1	8.5	.0	.0	8.5	42.0	9.4	+1.2				++	
307		30-48	"		9.2	8.5	120	8.0 1.25	8.5	.0	.0								++	
308		48-72	SCL		9.2	8.5	130	6.6 .95	9.0	.0	.0	90.0	31.0	15.0	-2.0				+	

Table 14
Sheet 9 of 18

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

otter Creek East SOIL LABORATORY - MILES CITY, MONTANA

UNIT Otter Creek-Mini Sites PROJECT

SOIL SCIENTIST Fiechtl LOCATION - SECTION 26 T. 55 R. 45E DATE 6-3-76

LAB NO.	PROFILE NO.	DEPTH INCHES	TEXTURE		pH		SET. VOL. ml	EC		FRAG. HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ.	PARTICLE SIZE PERCENTAGE			HCL	%
			FIELD	LAB	1-5	$CaCl_2$		1-5	SAT. EXT.	8 hr in./hr.	24 hr in./hr.	TSC me/l	Cat. Mg. me/l	SAR	me/100g	SAND	SILT	CLAY		
T309	19	0-6	SiCL		6.7		25	1.0 .13		.89	.84								++	
310		6-29	"		8.7	7.4	25	1.6 .20		.89	.88								++	
311		29-48	"		9.0	8.3	33	9.8 1.8	10.4	.0	.0	104.0	31.0	18.5	-4.8				++	
312		48-72	"		8.5		40	11.5 2.2	13.0	.28	.29	130.0	56.0	14.0					++	
313		72-96	"		8.8	8.1	60	7.8 1.2	9.5	.08	.07	95.0	42.5	11.4	even				++	
314		96-120	"		9.0	8.1	80	6.8 1.0	6.8	.0	.01								++	
315	20	0-12	CL		8.2		29	1.0 .13		1.28	1.40								++	
316		12-29	SiCL		8.1		25	16.3 3.8	18.0	.56	.54								++	
317		29-30	"		8.3		27	16.0 3.6	18.0	.30	.31								++	
318		30-42	"		8.7	8.3	40	13.0 2.6	15.0	.10	.09	150.0	75.5	12.1	-3.2				++	
319		42-60	"		8.7	8.4	40	10.5 1.8	12.0	.08	.08								++	

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

otter creek East SOIL LABORATORY - MILES CITY, MONTANA

UNIT otter Creek Mini Sites PROJECT _____

SOIL SCIENTIST Fiecht1 LOCATION- SECTION 26 T. 5S R. 45E DATE 6-3-76

LAB NO.	PROFILE NO.	DEPTH INCHES	TEXTURE		pH		SET. VOL. ml	EC		FRAG. HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE			HCL	%
			FIELD	LAB	1-5	$CaCl_2$		1-5	SAT. EXT.	8 hr in./hr.	24 hr in./hr.	TSC me/l	Cat.Mg. me/l	SAR		SAND	SILT	CLAY		
320	21	0-18	SiCL		8.3		25	1.2 .14		1.00	.92								H	
321		18-36	"		8.7	8.5	23	14.5 3.0	17.0	.72	.92								H	
322		36-60	"		8.6	8.4	25	15.0 3.3	14.0	.52	.50								H	
323		60-72	SiL		8.6	8.3	23	9.8 1.7	11.5	.35	.32								H	
324	22	0-12	FSL		8.4		19	1.0 .12		2.08	2.00								H	
325		12-30	"		8.4		19	.75 .10		1.52	1.40								H	
326		30-48	Lt FSL		8.6	7.9	17	1.8 .23		1.12	1.12								HH	
327		48-72	"		8.7	7.9	17	1.8 .23		2.20	1.80								HH	
328		72-96	"		8.9	7.8	18	1.0 .13		1.96	1.68								HH	
329		96-120	"(FS)		8.9	7.6	18	.75 .10		2.00	2.00								HH	

42

Table 14
Sheet 11 of 18

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

otter creek East SOIL LABORATORY - MILES CITY, MONTANA

UNIT otter Creek Mini Sites PROJECT

SOIL SCIENTIST Fiecht-l LOCATION- SECTION 26 T. 55 R. 45E DATE 6-3-76

LAB NO.	PROFILE NO.	DEPTH INCHES	TEXTURE		pH		SET. VOL. ml	EC		FRAG. HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ.	PARTICLE SIZE PERCENTAGE			HCL	%
			FIELD	LAB	1-5	$CaCl_2$		1-5	SAT. EXT.	8 hr. in./hr.	24 hr in./hr.	TSC me/l	Cat.Mg. me/l	SAR	me/100g	SAND	SILT	CLAY		
T330	23	0-12	SiCL		7.8		23	1.0 .13		2.16	2.12								-	
331		12-24	"	HV. CL	8.9	7.7	26	1.6 .20	1.4	.48	.58	14.0	4.6	6.2		37	26	37	H	
332		24-42	"		9.3	8.3	140	4.4 .58	4.0	.0	.0	40.0	7.4	16.9	Not run 0 HC				H	
333		42-66	CL		8.6	8.0	50	7.2 1.1	9.0	.29	.30								H	
334		66-84	SiCL		8.7	8.0	60	6.4 .90	8.0	.05	.07	80.0	35.0	10.8	even				H	
335		84-108	"		8.7	7.8	40	5.6 .77	6.5	.25	.25	65.0	27.2	10.2					H	
336		108-120	"		8.1		22	6.4 .93	7.0	1.08	1.00								H	
337	24	0-18	SiCL		8.2		23	1.1 .14		.92	.88								H	
338		18-42	"		8.0		21	3.8 .55		.92	.85								H	
339		42-60	"		8.1		20	2.8 .34		.76	.72								H	
340		60-84	"		8.1		21	2.4 .30		.68	.64								H	
341		84-108	"		8.1		22	2.5 .31		.44	.41								H	
342		108-120	"		8.2		20	2.2 .28		.44	.41								H	

Table 14
Sheet 12 of 18

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT Otter Creek East Otter Creek Minisites PROJECT _____

SOIL SCIENTIST Fiechtl LOCATION - SECTION 26 T. 5S R. 45E DATE 6-4-76

LAB NO.	PROFILE NO.	DEPTH INCHES	TEXTURE		pH		SET. VOL. ml	EC		FRAG. HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE			HCL	%
			FIELD	LAB	1-5	$CaCl_2$		1-5	SAT. EXT.	8 hr. in./hr.	24 hr. in./hr.	TSC me/l	Cat. Mg. me/l	SAR		SAND	SILT	CLAY		
T393	25	0-18	CL	CL	9.2	7.8	39	2.4 / 1.30	2.0	.09	.03	20.0	3.9	12.7	+.90	39	30	31	#	
394		18-42	SiCL		8.8	8.5	60	14.5 / 3.0	14.0	.05	.04	140.0	57.0	15.5	-1.2				#	
395		42-54	"		8.9	8.5	100	15.0 / 3.2	15.0	.0	.02								#	
396		54-72	"		8.7	8.5	100	16.5 / 3.8	14.0	.0	.09	140.0	46.0	19.6	-3.6				#	
397		72-96	CL		8.9	8.5	95	12.5 / 2.9	15.0	.07	.08								#	
398		96-120	SiCL		8.9	8.5	100	14.5 / 3.0	16.0	.0	.02								#	
349	26	0-18	SiCL		8.1		22	2.6 / 1.32		1.12	1.02								#	
350		18-42	"		8.2		30	9.0 / 1.5	9.0	.29	.28	90.0	75.0	2.5					#	
351	27	0-18	SiCL		8.3		23	1.4 / .18		1.00	.84								#	
352		18-42	"		8.6	8.4	21	14.5 / 3.0	18.0	.60	.56								#	
353		42-66	"		8.7	8.4	25	10.5 / 1.9	13.0	.30	.30								#	
354		66-84	"		7.2		45	10.0 / 1.8	10.0	.18	.18								Tr	
355		84-108	"		5.7	5.2	36	5.2 / .70	4.5	.02	.02								—	

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

ottercreek East SOIL LABORATORY - MILES CITY, MONTANA

UNIT otter Creek Mini sites PROJECT _____

SOIL SCIENTIST Fiechtl LOCATION - SECTION 26 T. 5S R. 45E DATE 6-9-76

LAB NO.	PROFILE NO.	DEPTH INCHES	TEXTURE		pH		SET. VOL. ml	EC		FRAG. HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE			HCL	%
			FIELD	LAB	1-5	$CaCl_2$		1-5	SAT. EXT.	8 hr. in./hr.	24 hr in./hr.	TSC me/l	Cat.Mg. me/l	SAR		SAND	SILT	CLAY		
T356	2B	0-12	CL		8.3		21	.75 .10		1.20	1.60								H	
357		12-30	SiCL		8.1		24	5.3 .73	5.0	.56	.60								H	
358		30-98	>"		7.9		38	9.8 1.7	8.5	.13	.18	85.0	77.0	1.3					H	
359		98-66	>"		8.2		45	6.6 .55	5.5	.10	.11	55.0	46.0	1.9	-1.0				H	

Table 14
Sheet 14 of 18

UPPER MISSOURI PROJECTS OFFICE

Soils Laboratory

Sodium Adsorption Ratio Analysis

Fiechtl — other Creek East

Sample No.	EC10^3	Total soluble cations	Ml. of Extract	Ml. of Titraver	MC/L Ca & Mg	MC/L Na	S.A.R.
251	2.5	25.0	5	.95	3.8	21.2	10.4
252	12.0	120.0	2	4.3	43.0	77.0	14.6
253	7.5	75.0	2	2.3	23.0	52.0	15.3
278	1.5	15.0	10	1.9	3.8	11.2	8.1
279	2.1	21.0	5	1.0	4.0	17.0	12.0
289	1.75	17.5	10	1.2	2.4	15.1	13.8
290	2.0	20.0	10	1.5	3.0	17.0	13.9
294	2.8	28.0	5	1.4	5.6	22.4	13.4
302	14.0	140.0	2	7.0	70.0	70.0	11.8
306	8.5	85.0	2	4.2	42.0	43.0	9.4
308	9.0	90.0	2	3.1	31.0	59.0	15.0
311	10.4	104.0	2	3.1	31.0	73.0	18.5
312	13.0	130.0	2	5.6	56.0	74.0	14.0
313	9.5	95.0	2	4.25	42.5	52.5	11.4
318	15.0	150.0	2	7.55	75.5	74.5	12.1
331	1.4	14.0	10	2.3	4.6	9.4	6.2
332	4.0	40.0	5	1.85	7.4	32.6	16.9
212	9.0	other creek East 90.0	2	3.8	38.0	52.0	11.9
215	18.0	180.0	2	10.95	109.5	70.5	9.5
216	16.0	160.0	2	7.25	72.5	87.5	14.5
218	13.0	130.0	2	5.55	55.5	74.5	14.1
219	13.0	130.0	2	5.75	57.5	72.5	13.5
227	1.35	13.5	10	1.4	2.8	10.7	9.0
228	9.0	90.0	2	4.4	44.0	46.0	9.8
230	5.5	55.0	5	4.1	16.4	38.6	13.5
231	4.5	45.0	5	1.8	7.2	37.8	19.9
233	16.0	160.0	2	5.0	50.0	110.0	22.0
234	19.0	190.0	2	6.6	66.0	124.0	21.6
235	10.0	100.0	2	2.1	21.0	79.0	24.4
248	3.3	33.0	5	1.9	7.6	25.4	13.0

Sec. 26, T5S., R45E., Custer County, Montana

otter creek East LABORATORY RECORD ~~Sodium Status~~ Gyp Req.
Great Falls

Fiechtl Mini sites

Sample	Sodium Status: mmhos	EDTA: cc	Status	Size Sample	Gypsum Requirement: cc. EDTA Total	cc. EDTA by ca.	cc.	Value
279							6.1	0
291							5.9	+.8
294							6.1	0
~~303~~							5.8	+1.2
~~308~~							6.6	-2.0
~~311~~							7.3	-4.8
313							6.1	.0
318							6.9	-3.2
~~322~~								
334							6.1	0
343							6.0	+.1
344							6.4	-1.2
346							7.0	-3.6
359							6.35	-1.0
212							6.8	-2.8
~~215~~								
~~218~~								
219							6.4	-1.2
~~227~~								
230							6.2	-.4
~~234~~								
234							6.6	-2.0
~~238~~								
~~254~~								
~~263~~								

otter creek East

SOILS LABORATORY
GREAT FALLS, MONTANA
ANALYSES - MOISTURE EQUIVALENT

Mini sites

Dam

otter creek East

Field No.	Lab. No.	Depth inches	Percent gravel	Mech. Analysis % sand	% silt	% clay	Lab. text.	Field text.	M.E.	M.E. gr.at 0	M.E. wtd.avg 0 - 49"
T298	18			27	40	33	CL	L			
T251	19			33	34	33	CL	SiCL			
T279	20			31	38	31	CL	SiCL			
T289	21			45	32	23	HVL	SiCL			
T290	22			33	28	39	HVCL	SiCL			
T331	23			37	26	37	HVCL	SiCL			
T343	24			39	30	31	CL	CL			

REPORT OF MASTER SITE SOIL ANALYSES

US BUREAU OF RECLAMATION
MISSOURI SOURIS PROJECTS OFFICE
BISMARCK, NORTH DAKOTA

DATE RECEIVED _____

AREA Otter Creek East SECTION _____ TOWNSHIP _____ RANGE _____ INVESTIGATOR DuPree SOIL TYPE _____ LAND CLASS _____ DATE REPORTED _____

Lab Number	Boring Number	Depth in Inches	Field Texture	Particle Size Analysis: % Sand, dia. in mm 2.0–1.0 VCo	1.0–0.5 Co	0.5–0.25 Med	0.25–0.10 Fine	0.10–0.05 VFine	% Silt	% Clay	Lab Test	Moisture Retention: % Pressure in Bars 0.10	0.33	15	Hyd Cond in/hrs 6 Hr	24 Hr	Sat Vol ml	pH (1:5) H_2O	pH (Sat Paste)	$EC_e \times 10^3$ mmhos/cm @ 25°C	Saturation Extract: Cations, me/l Ca	Mg	Na	K	Anions, me/l Carbon.	CO_3	HCO_3	Cl	SO_4	SAR	SP	Total Extractable Cations me/100g Ca	Mg	Na	K	Exchangeable Cations me/100g Ca	Mg	Na	K	ESP	% Base Sat	Gyp me/100g	Gyp Req me/100g	% $CaCO_3$ Equiv	% Org-C	% Field Wash. Coh	Bulk Density g/cm³	Field Hyd Cond. in/hr	Field infiltrance in/hr	EC Trophicity
6899	(S)	0–36		84	11	24	26	624	159	111	45	LFS	58	101	22	128	120	18	89	79	0.19	1.0	1.37	4.41	4.83	0.21	11.02	0.08	2.52	0.28	7.31	0.10	2.8	31.8	0.04	0.15	0.13	0.01				0.12	0.45									1.7
900	(S)	36–100		42						656	282	SCL	31.3	25.5	12.0	0.00	0.00	65	8.7	7.7	0.34	2.1	2.14	2.35	6.74	0.69	12.96	0.48	6.72	0.00	13.97	0.06	11	42.5	0.09	0.10	0.71	0.03				1.39	2.13									3.6
1	(S)	57–162		8.0						417	563	SiC	55.2	50.8	20.0	0.00	0.00	270	9.2	8.2	0.46	1.4	0.22	2.09	15.00	0.18	15.49	0.64	6.40	9.04	7.49	0.09	38	79.4	0.02	0.01	1.19	0.01				6.37	8.51	35								8.2
2	(S)	162–175		33.5						450	25.5	L	35.0	27.8	9.9	0.00	0.00	115	9.6	8.0	0.46	1.1	0.49	0.59	14.70	0.20	15.93	0.72	5.88	0.52	9.18	0.09	20	52.4	0.03	0.03	0.77	0.01				3.65	0.21									7.8
3	(S)	175–210		67.7	2.0	4.8	6.5	35.0	19.4	204	11.9	FSL	27.6	19.2	5.5	0.00	0.00	65	8.9	7.7	0.40	3.2	1.70	1.09	28.00	0.41	31.20	0.24	4.00	0.00	27.42	0.10	2.4	46.0	2.98	0.05	1.29	0.02				2.52	0.13									5.5
6904	(S)	210–234		2.8						756	21.6	SiL	22.5	23.6	8.7	0.00	0.01	48	9.0	7.8	0.34	2.6	1.43	1.00	22.17	0.93	25.19	0.48	8.48	0.04	15.91	0.03	2.0	76.6	0.05	0.04	0.81	0.02				1.30	0.12									9.0

Horizon	Depth in Inches	Color Dry	Color Moist	Texture	% Co Fragments > 2 mm	Structure	Consistance Dry	Consistance Moist	Consistance Wet	Mottling	Reaction Field	Boundary	Roots	Pores	Clay Films

Land Use
L N Veg or Crop
Parent Material
Soil Survey Designation
Physiography
Relief
Elevation
Slope
Aspect
Erosion
Permeability
Drainage
Ground Water
Moisture
Root Distrib
Date of Profile Description
Climate
Salt or Alkali
Stoniness
Category
Present Land Class
Additional Notes

Table 14
Sheet 18 of 18

Form 1279–3
(June 1984)

BORROWER'S CARD

TD 195 .U2S E47 no.47 c.3
Oil or Uncal east study area,
Colo. Dept. contract

DATE LOANED	BORROWER	OFFICE	DATE RETURNED

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(Continued on reverse)

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